917

SUPREME COURT OF THE UNITED STATES.

No. ~~228~~ 160-69.

THE WHEELER AND WILSON MANUFACTURING COMPANY, APPELLANTS,

vs.

GEORGE H. CORLISS.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE DISTRICT OF CONNECTICUT.

GOVERNMENT PRINTING OFFICE.

919

SUPREME COURT OF THE UNITED STATES.

No. 228.

THE WHEELER AND WILSON MANUFACTURING COMPANY, APPELLANTS,

vs.

GEORGE H. CORLISS.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE DISTRICT OF CONNECTICUT.

INDEX.

	Original.	Print.
Clerk's certificate	1	1
Bill of complaint	2	1
Exhibits B, C, F, and G	4	5
Answer	15	23
Exhibits A, B, J, L, M, N, O, P, Q	27	38
Exhibits C, D, E, F, G, H	54	71
Decree	107	96
Final decree	112	98
Appeal	113	98
Plaintiff's testimony	114	101
Defendant's testimony	262	209
Eight maps	416	318

said date thereof, the full and exclusive right and liberty of making, using, and vending to others to be used, the said improvement in cut-off and working valves of steam-engines, as by the final reissue of said letters patent to be presently referred to and now produced and shown to your honors will more fully appear.

And your orator further shows unto your honors that afterwards, to wit, before the 13th day of May, in the year 1851, the said letters patent, being believed to be inoperative and invalid by reason of a defective specification, were surrendered according to law, and cancelled, and new letters patent of the United States for the said invention, but on an amended specification, bearing date the 13th day of May, in the year 1851, sealed with the seal of the Patent Office, signed by the Secretary of the Interior, and countersigned by the Commissioner of Patents, were, on said 13th day of May, issued and delivered to your orator, whereby there was granted to him, his heirs, executors, administrators, or assigns, for the remainder of the term of fourteen years from the 10th day of March, in the year 1849, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improvement in cut-off and working valves of steam-engines, as by the final reissue thereof, next to be referred to, and here in court to be produced and shown to your honors, will more fully appear.

And your orator further shows unto your honors that afterwards, to wit, before the 12th day of July, in the year 1859, the said reissued letters patent, also being believed to be inoperative and invalid by reason of a defective specification, were surrendered according to law, and cancelled, and six several new letters patent, each on a distinct and amended specification, and each bearing date the 12th day of July, in the year 1859, and sealed with the seal of the Patent Office, signed by the Secretary of the Interior, and countersigned by the Commissioner of Patents, were, on said 12th day of July, issued and delivered to your orator for the several and distinct improvements embraced by his said invention, whereby there was granted to your orator, his heirs, administrators, or assigns, for the remainder of the term of fourteen years from the 10th day of March, in the year 1849, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said several improvements, as in and by said several reissue letters patent here in court to be produced and shown to your honors will more fully appear.

And your orator further shows unto your honors that, on the 29th day of July, in the year 1851, your orator being the original and first inventor of a certain other new and useful invention of an improved cut-off gear, which was not known or used prior to his said invention or discovery thereof, nor in public use, nor on sale with his consent or allowance more than two years prior to his application hereinafter mentioned, and having made application in due form of law to the government of the United States for their letters patent therefor, and due proceedings having been had on such application, letters patent of the United States, bearing date the 29th day of July, in the year

1851, sealed with the seal of the Patent Office, signed by the Secretary of the Interior, and countersigned by the Commissioner of Patents, were, on said 29th day of July, issued and delivered to your orator for the said improvement, whereby there was granted to him, his heirs, executors, administrators, and assigns, for the term of fourteen years from the aforesaid date thereof, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improved cut-off gear, as by the reissue of said letters patent to be presently referred to and produced and shown to your honors will more fully appear.

And your orator further shows unto your honors that afterwards, and before the 26th day of July, in the year 1859, the said letters patent, being believed to be inoperative and invalid by reason of a defective specification, were surrenered according to law, and cancelled, and new letters patent of the United States for the said invention, but on an amended specification, bearing date the 26th day of July, 3 in the year 1859, sealed with the seal of the Patent Office, signed by the Secretary of the Interior, and countersigned by the Commissioner of Patents, were, on said 26th day of July, issued and delivered to your orator, whereby there was granted to him, his heirs, administrators, or assigns, for the remainder of the term of fourteen years from the 29th day of July, in the year 1851, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improved cut-off gear, as by said reissue patent now produced and shown to your honors will more fully appear.

And your orator further shows unto your honors that upon the issuing of the said several reissued patents now existing, he put into use the several improvement by them respectively secured, and that he has been ever since, and now is, except for the doings of this defendant and its confederates, as hereinafter set forth, and of other wrong-doers in the premises, in the exclusive possession and enjoyment thereof, and of each of them, and that the several rights secured thereby have been and are of great value to your orator.

And your orator further shows unto your honors that the defendants herein having full knowledge of the premises, and in violation of your orator's exclusive rights and privileges aforesaid, and utterly disregarding the same, and against the will and without the license or acquiescence of your orator, and without right, and combining and confederating for that purpose with other parties at present unknown to your orator, but whose names, when discovered, he prays he may be at liberty herein to insert and make parties defendant hereto, with apt words to charge them, has, since the date of the issuing of the last of the said now existing reissue patents, at Bridgeport, in the State and district of Connecticut, and in divers other parts of the United States, used and exercised, and still continues to use and exercise, and is about still further to use and exercise the several improvements and machinery constructed on the principle of, and embracing the several improvements described and claimed in, and the right to use and exercise which is exclusively vested in your

orator by the aforesaid existing reissue patents, which are numbered 759, 760, and 763, respectively, being each for an improvement therein entitled "A new and useful improvement in cut-off and working valves of steam-engines," and each dated the 12th day of July, in the year 1859, and that which is numbered reissue 780 being for an improvement therein entitled "A new and useful improved cut-off gear," and bearing date the 26th day of July, in the year 1859, of which four last-mentioned reissue patents and the descriptions accompanying them, copies lettered B, C, F, and G, respectively, are hereunto, for greater convenience and certainty, annexed and made part of this bill.

And your orator has requested the defendants herein to desist from their unlawful acts aforesaid, which they utterly refuse to do, but continue therein to the great and irreparable loss and injury of your orator, contrary to equity and good conscience, and in contravention of your orator's just rights in the premises.

And your orator further shows unto your honors that Nathan Wheeler, joined in this bill as defendant with the said Wheeler & Wilson Manufacturing Company, is, as hereinbefore described, an officer of said company and an active manager of its business, and actually and personally concerned in the use of your orator's improvement aforesaid, and well acquainted with its business, and able to answer, upon his personal knowledge or information and belief, whether or not these your orator's charges are true.

To the end, therefore, that the said defendant may, if it can, show cause why your orator should not have the relief hereby prayed, and may the said Wheeler & Wilson Manufacturing Company, in its corporate capacity, under its corporate seal, and the said Nathan Wheeler, upon his corporal oath, and all to the best and utmost of their knowledge, remembrance, information, and belief, full, true, direct, and perfect answer make to all and singular the matters and things hereinbefore stated and charged, as fully and particularly as if the same were hereinafter repeated and they thereunto distinctly interrogated, and more especially that they may severally answer in manner aforesaid, whether the said Wheeler & Wilson Manufacturing Company has not used and exercised, since the issuing the last of the said existing reissue patents to your orator, machines embracing in their construction and operation the improvements described and claimed in the said reissue patents, and particularly those of which copies are hereto annexed, or in what respects differing therefrom, and how many such machines, and for how long a time, and from whom the said Wheeler & Wilson Manufacturing Company purchased the same, and when and what amount of saving per day, on an average, has been effected by such use, and what amount of profit has been received by said company from said use, and whether further use thereof is not intended.

May it please your honors to grant unto your orator a writ of subpœna, directed to the said defendants, commanding them to appear and answer to this bill of complaint, and also a writ of injunction issuing out of this honorable court to restrain the defendant company

from using any machinery constructed according to the direction or description in, or any machinery in violation of, your orator's said reissue patents, or any of them, and also that the defendant company be decreed to account for and pay over to your orator all said gains and profits as it may have made by the use of said machinery, and that the said machinery now in possession of the defendant company may be destroyed or delivered up to your orator, and that his said reissue patents may be decreed to be valid, and machinery such as that used by the defendant company an infringement thereon, or for such other or future relief as the nature of the case may require and to your honors may seem meet.

And your orator will ever pray.

GEORGE H. CORLISS.
ROGER S. BALDWIN,
Of Counsel for Complainants.

RHODE ISLAND DISTRICT, *ss:*

In the city of Providence, this 10th day of November, A. D. 1859, then George H. Corliss personally appeared and made oath that the facts in the foregoing bill stated of his own knowledge and belief are true, according to the best of his information and belief, before me.

SAM'L W. PERAHUM,
Commissioner of the U. S. Circuit Court for said R. I. District to take affidavits, bail, &c.

4 B.

Reissue No. 759.

The United States of America to all to whom these letters patent shall come:

Whereas George H. Corliss, of Providence, Rhode Island, has alleged that he has invented a new and useful improvement in cut-off and working valves of steam-engines, (for which letters patent were issued to him, dated March 10, 1849, the same surrendered and new letters issued to him, dated May 13, 1851, which last letters having been surrendered by him, the same have been cancelled and new letters ordered to issue to him on six amended specifications,) which he states has not been known or used before his application, has made oath that he is a citizen of the United States; that he does verily believe that he is the original and first inventor or discoverer of the said improvement, and that the same hath not, to the best of his knowledge or belief been previously known or used; has paid into the treasury of the United States the sum of thirty dollars, and presented a petition to the Commissioner of Patents signifying a desire of obtaining an exclusive property in the said improvement, and praying that a patent may be granted for that purpose:

These are therefore to grant, according to law, to the said George H. Corliss, his heirs, administrators, or assigns, for the term of fourteen years from the tenth day of March, one thousand eight hundred and forty-nine, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improve-

ment, a description whereof is given in the words of the said George H. Corliss, in the schedule hereunto annexed, and is made part of these presents.

In testimony whereof, I have caused these letters to be made patent and the seal of the Patent Office has been hereunto affixed.

Given under my hand, at the city of Washington, this twelfth day of July, in the year of our Lord one thousand eight hundred
[L. S.] and fifty-nine, and of the independence of the United States of America the eighty-fourth.

JACOB THOMPSON,
Secretary of the Interior.

Countersigned and sealed with the seal of the Patent Office.

WM. D. BISHOP,
Commissioner of Patents.

5 No. 759.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, George H. Corliss, of the city and county of Providence, in the State of Rhode Island, have invented a new and useful improvement in the valve apparatus of steam-engines, and that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, in which fig. 3 represents, in elevation, the valve mechanism of a beam engine, to which my invention has been applied; fig. 4 is a top view of certain portions of the same; and fig. 5, a view of certain parts of the valve gear, detached from the remainder.

The invention which is the subject of this patent is applicable to engines in which steam or other elastic fluid is used expansively, and has reference to the apparatus by means of which the steam or other elastic fluid is admitted into the cylinder. The openings or ports through which steam is admitted into the cylinder and discharged therefrom are opened and closed by valves which are located in valve chests, and are moved at suitable intervals to open and close the ports by means of mechanism which is commonly termed the *valve gear* of the engine. In engines in which steam is used expansively, the valve is made to close its port after a portion only of the stroke of the piston is completed, to cut off the flow of steam from the boiler, and permit that in the cylinder to expand.

In order thus to cut off the steam, various valve apparatus have been devised, which differ from each other either in the kind of valve, or of valve gear employed, or in both of those particulars. In order to the introduction of my improvement in any steam-engine, it is requisite that a liberating valve gear shall be provided—that is to say, a valve gear which embodies two forces for operating the steam valves; the one for their opening movement may be derived

from the engine itself; the other, for the closing movement, may be derived from weights or springs; and, whilst the arrangement may be such that the reciprocal operations of these two forces may give the proper movements for closing the valves at certain fixed periods of the stroke of the piston, there must be embodied a provision for effecting the closing of the valves at variable periods of the stroke, by such a release of that portion of the valve gear actuated by one force from that actuated by the other force, as will anticipate the time at which the valves would be closed if their closing was effected by the return movements of the opening mechanism.

Prior to my invention the liberating valve gear was applied to operate valves of the species known as puppet or lifting valves, which valves are operated by being moved perpendicularly to the plane of their seats.

As each valve of this species moves *from* its seat in opening, and *to* its seat in closing, the commencement of the opening of the steam port is coincident with the commencement of the movement of the valve from a state of rest, and the completion of the closing of the steam port is coincident with the return of the valve to a state of rest. But in order to use steam expansively with the best effect, it is necessary, and particularly in fast-moving engines, that the valve should move with rapidity in opening, so as to admit the steam at its full pressure into the cylinder, and that the valve should also move with great rapidity in closing, so as to avoid what is technically termed the throttling of the steam. Now it is obvious that the immediate starting of a valve from a state of rest into rapid motion to effect the opening of the steam port must be attended with concussion, or at least with a severe strain upon the mechanism which actuates it; and a severe concussion must also occur in suddenly bringing the valve to rest, from a state of rapid motion, in order to effect the closing of the steam port. It has, therefore, been found necessary in practice to provide for a gradually accelerated movement of lifting valves as they move from their seats to open, and a gradually retarded movement as they are returned to their seats to close.

Economy in the use of steam has thus been sacrificed to the necessity of obviating the inherent practical defects which attend the use of lifting valves. Their employment is also attended with the disadvantage that as they approach their seats the action of the steam tends to accelerate their movement, and thus increases their tendency to slam upon their seats. The object of my invention is to obviate the foregoing among other defects in previous valve apparatus of steam-engines, without sacrificing the important advantages resulting from the rapidity of movement which can be imparted to the valve by weights, springs, or the equivalents thereof, in cutting off the steam; and it consists in combining a slide valve that moves beyond, or overlaps its port, with liberating valve gear, whereby the valve, although started slowly from a state of rest, will be in rapid motion when the steam port begins to open, and, although returned to a state of rest with a retarded movement, it will be in rapid motion under the action of a weight or spring, or its equivalent, at the time

the port is being closed—the commencement of the opening of the port in this combination being subsequent to, instead of coincident with, the commencement of the movement of the valve, and the closing of the port being prior to the return of the liberated valve to a state of rest, instead of coincident therewith.

My present invention is represented in the accompanying drawings in connection with other inventions, for which patents, bearing even date herewith, have been granted to me. As, however, it may be used without the other improvements, and as these may be used independently of it, I shall, in the present specification, describe only so much of the mechanism of the steam-engine as I deem necessary to communicate a clear understanding of the invention herein claimed. The cylinder of this engine is constructed with four ports, to each of which a valve is applied. Two of these valves (*l* and *l*) are for opening ports, at proper intervals, to admit steam into the cylinder, and for closing them to stop its admission; the two remaining valves (*m* and *m*) are for opening other ports, at proper intervals, to permit the steam to escape from the cylinder after it has done its work, and to close them, at proper intervals, and keep them closed while steam is acting upon the piston.

In order to operate the steam valves (*l* and *l*) they are connected with valve gear, which is constructed in parts, one of which is permanently connected with each valve; while the other part is connected with an eccentric secured to the crank shaft, so that it is constantly moved by the power of the engine while the latter is in operation. The part of this valve gear connected permanently with each valve consists of a double valve rod, (*b'*,) upon which a weight (*o'*) is arranged to act, through the intervention of a bent lever or bell crank, (*m'*,) to cause the valve to close its port whenever the part of the valve gear connected with it is separated from the remainder of the valve gear. The other part of the valve gear consists, in this instance, of two sliding blocks, (g' g';) the bell cranks (*f' f'*) having teeth that engage with corresponding teeth in the blocks; the wrist plate (*x*) and its appurtenances; and the eccentric (*a'*) with its appurtenances—the latter, in its revolution, causing the sliding blocks to traverse to and fro. The part of the valve gear connected permanently with each valve is fitted with a variable link or medium of connection, (*h'*,) which is hinged to the valve rod (*b'*,) and has an acting face, (*c*,) which can be placed in contact with a corresponding face (*e*) formed upon the adjacent sliding block. When these two faces are in contact, the part of the valve gear connected permanently with the valve is moved along with the remainder, so that the valve is drawn open and the weight lifted by the power of the engine; the two acting faces (*c e*) remaining in contact until a separation is made by a lateral movement of the one to the other. Such a lateral movement is effected, in the present example, when steam is to be cut off, by means of a cam, (*k'*,) which is turned by the power of the engine, through the intervention of a series of shafts and wheels, the last of which is secured to the crank shaft; and, as in this engine, the shank of the link is not

within the range of motion of the cam, a projection (*j'*) is secured to the link upon which the cam bears when the separation of the one part of the valve gear from the other, and the consequent liberation of the steam valve with its weight, from the opening mechanism, takes place, and the valve is then instantly closed by the power of the weight. Each steam valve (*l*) is constructed in such manner that when it is at rest it overlaps its port; hence the valve may be moved a certain distance from its state of rest before it is time to commence the opening of its port, and, as such a preliminary movement of the valve does not affect the distribution of the steam, it may be effected with any degree of speed that may be deemed advisable; the valve may therefore be started slowly from its state of rest, and be moved with gradually accelerated speed, so as to attain a rapid movement at the instant it begins to uncover its port; and the operation of the valve gear is such that this kind of opening movement is imparted to the valve. On the other hand, the movement of the valve in returning, after opening its port, does not terminate at the instant at which the port is covered, as the valve continues to move until it has regained its lap; hence a rapid movement of the valve in closing may be maintained until the port is entirely closed, after which the movement of the valve may be gradually retarded until it resumes its state of rest; or, if the movement be not gradually retarded so as to bring the valve gradually to rest, all concussion of the valve may be avoided by transferring the blow that would result from stopping the motion of the valve and of the parts connected therewith to some part of the valve gear which would not be injured by the shock.

There is thus, as I have discovered, a peculiar adaptation of the properties of the liberating valve gear to the properties of the overlapping slide valve; for while the liberating system permits the valve to be closed with great speed, independently of the opening mechanism, by the force of gravity or springs, the space through which the valve may be moved beyond its port before it is brought to rest affords ample time to bring it gradually to a state of rest without in the least degree retarding the speed with which it closes its port; and even if the valve be not gradually brought to a state of rest, it need not suffer concussion, as it is not necessary that it should, like a lifting valve, collide with a stationary part of the engine.

Moreover, after the port is covered, the pressure of the steam from the boiler on the back of the valve is greater than that of the steam within the port on its face, and this pressure, by pressing the valve upon the seat on which it slides, produces friction, which tends to retard its motion. As, however, friction alone is not sufficient, in the present engine, to bring the valve gradually to rest as soon as is desirable, and prevent the jar which would result from the sudden stoppage of the motion of the weight, each cross-block (*N*) has a cylindrical socket (*n'*, fig. 7) to contain atmospheric air open towards the steam cylinder, and a piston (*p'*) is secured to the engine frame in such a position that it enters the socket, and, fitting the same, the air is compressed therein, as the valve closes, to form an elastic cushion to prevent the jar. In order that each steam valve may

uncover its port at the proper moment to admit steam to the cylinder, the adjacent member of the part of the valve gear appertaining to the eccentric, which in this instance is the sliding block, (g′,) is moved back by the eccentric, turned by the power of the engine into such a position that the link (*h′*) can be moved laterally to place its acting face within the range of motion of the face upon the sliding block, when the latter is again moved to draw the valve along; this movement of the valve gear takes place before the piston of the engine is ready to make its stroke from the adjacent end of the cylinder, and the lateral return movement of the link is effected by a spring, (*i″*.)

As it is desirable that the flow of steam to the cylinder should be cut off at different periods of the stroke of the piston according to the requirements of the work, the cams (*k′*) are helical; that is to say, the projecting part thereof extends around the shaft in a helical line, and the cam shaft is constructed to slide endwise in its boxes, so that it may be moved up or down to cause the cams to act sooner or later upon the links of the valve gear. As, however, the present invention may be used without varying the period of cut-off, and, as neither the mode of varying the period nor the means of accomplishing this operation form part of the invention herein claimed, it is not deemed necessary to describe either of them more particularly, especially as they are fully described in other letters patent granted to me of even date herewith.

Having thus described my invention and one mode of embodying it in a working engine, I wish it to be understood that by the term "liberating valve gear," as I have used it in this specification, I do not include those previous arrangements for working valves, which consist of cams of various forms, to open the valves, and then, at certain periods of their rotation, suffer the valves to be closed by the force of weights or springs, but control and graduate the closing movement. Such arrangements of valve gear lack the capacity for varying the periods of closing the valves combined with the promptness of closing at all speeds of the engine, which characterizes my improved valve gear; and they differ from it also in other essential features; and, though cams of various kinds may be used to open the valves in connection with my improved valve gear, and weights or springs used to affect the closing of the valves, yet some arrangement is indispensable for releasing the valves at variable periods from the control of the cam which opens them to anticipate the return movement which would otherwise occur by the regular operation of the cam in its rotation. But I do not limit myself to any particular construction of the valve so long as it moves across the port and overlaps it in closing, in contradistinction to shutting against a seat as a lifting valve does; or, in other words, so long as the valve is so constructed that its progressive motion can precede the opening of the port, and continue after its closing; neither do I confine myself to a liberating valve gear of any peculiar construction. But what I claim as my invention and desire to secure by letters patent is—

The combination of liberating valve gear with valves, which are moved parallel to their seats, and continue their closing motion after

their ports are closed, and commence their opening motion before their ports open, substantially as described.

In testimony whereof, I have hereunto subscribed my name.

(Signed) GEORGE H. CORLISS.

Witnesses:

HENRY BALDWIN, Jr.

JOHN S. HOLLINGSHEAD.

7 C.

Reissue No. 760.

The United States of America to all to whom these letters patent shall come:

Whereas George H. Corliss, of Providence, Rhode Island, has alleged that he has invented a new and useful improvement in cut-off and working valves of steam-engines, (for which letters patent were issued to him, dated March 10th, 1849, the same surrendered and new letters issued to him, dated May 13th, 1851, which last letters having been surrendered by him, the same have been cancelled and new letters ordered to issue to him on six amended specifications,) which he states has not been known or used before his application, has made oath that he is a citizen of the United States; that he does verily believe that he is the original and first inventor or discoverer of the said improvement, and that the same hath not, to the best of his knowledge or belief, been previously known or used; has paid into the treasury of the United States the sum of thirty dollars, and presented a petition to the Commissioner of Patents signifying a desire of obtaining an exclusive property in the said improvement, and praying that a patent may be granted for that purpose.

These are therefore to grant, according to law, to the said George H. Corliss, his heirs, administrators, or assigns, for the term of fourteen years from the tenth day of March, one thousand eight hundred and forty-nine, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improvement, a description whereof is given in the words of the said George H. Corliss, in the schedule hereunto annexed, and is made part of these presents.

In testimony whereof, I have caused these letters to be made patent, and the seal of the Patent Office has been hereunto affixed.

Given under my hand, at the city of Washington, this twelfth day of July, in the year of our Lord one thousand eight hundred and fifty-nine, and of the independence of the United States of America the eighty-fourth.

[L. S.]

JACOB THOMPSON,
Secretary of the Interior.

Countersigned and sealed with the seal of the Patent Office.

WM. D. BISHOP,
Commissioner of Patents.

8 No. 760.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all whom it may concern:

Be it known that I, George H. Corliss, of the city and county of Providence, and State of Rhode Island, have invented a new and useful method of arresting the movement of valves in engines, and that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, in which fig. 3 represents, in elevation, the valve mechanism of a beam engine, to which my improvement has been applied; fig. 4 is a top view of certain portions of the same; and fig. 5 a view of certain parts of the valve gear detached from the remainder; fig. 6 an end view of the air cylinder; and fig. 7 a section through the axis of the air cylinder and piston.

The invention, which is the subject of this patent, is applicable to engines in which a liberating valve gear is used, and the valves are closed independently of the power of the engine; and its object is to arrest the movement of the liberated valves, and that of the parts with which they are connected, without injurious jar or concussion. My method of accomplishing this result consists in enclosing a quantity of air in a vessel, by the movement of devices connected with the valve gear, in such manner that the valve cannot close without the compression of this enclosed air, which forms an elastic cushion to retard the movement of the parts and prevent jar.

This invention is represented in the accompanying drawings as applied to the valve apparatus of an engine embodying other inventions, for which patents, bearing even date herewith, have been granted to me. As, however, it may be applied with greater or less advantage to valve apparatus which does not embody these inventions, and as these may be used independently of it, I shall, in the present specification, describe only so much of the mechanism of the steam-engine as I deem necessary to communicate a clear understanding of the invention which is the subject of this patent. The mechanism represented in the accompanying drawings for operating the steam valves (l, l,) is constructed in parts, one of which is connected permanently with each valve, while the other part is connected with an eccentric, so that it is constantly moved by the power of the engine, while the latter is in operation. The part of this valve gear connected permanently with each valve consists of a double valve rod, (b',) upon which a weight (o') is arranged to act, through the intervention of a bent lever or bell crank, (m',) to cause the valve to close its port whenever the part of the valve gear connected with it is separated from the remainder of the valve gear. The other part of the valve gear consists, in this instance, of the sliding blocks (g', g',); the bell cranks (f', f',) having teeth that engage with corresponding teeth in the blocks; the wrist plate, (x,) and its appurtenances; and the eccentric,

with its appurtenances, which, in its revolution, causes the sliding blocks to traverse to and fro. The part of the valve gear connected permanently with each valve is fitted with a variable link, (h',) which is hinged to the valve rod, (b',) and has an acting face, (c) which can be placed in contact with a corresponding face, (e,) formed upon the adjacent sliding block (g'). When these two faces are in contact, the part of the valve gear connected permanently with the valve is moved, along with the remainder, so that the valve is drawn open by the power of the engine; and as the weight (o') is constantly tending to move the valve back over its port, the two faces remain in contact until a separation is made by a lateral movement of one to the other. Such a lateral movement is effected, in the present example, when steam is to be cut off, by means of a cam, (k',) which is turned by the power of the engine, through the intervention of a series of shafts and wheels, the last of which is secured to the crank shaft; and, as in this engine the shank of the link is not within the range of motion of the cam, a projection (J') is secured to the link, upon which the cam bears when the separation of one part of the valve gear from the other, and the consequent liberation of the steam valve from the control of the power of the engine, takes place.

In order to arrest the movement of the valve, the weights, and the parts connected therewith, after liberation, a cross-block, (N,) having a cylindrical socket (n') formed in it, and opening towards the valve, (it is shown on a large scale at figs. 6 and 7,) is secured to each valve rod. and a piston (p') is secured to the engine frame in such a position that it enters the cylindrical socket and encloses air therein, as the weight (o') falls. The piston fits the cylinder sufficiently close to prevent the free escape of the enclosed air, so that the latter is compressed by the piston, and opposes the elastic resistance of an air-cushion, to arrest the movement of the parts, and bring them gradually to rest. An orifice (z) is made in the side of the cylinder, near its bottom, to permit the free escape of the air therefrom, until the piston has advanced nearly to the bottom of the cylinder, which position it reaches about the time the steam valve closes its port, when the air piston, passing the orifice in its cylinder, closes it to prevent the further escape of the air, which, by the continued movement of the piston, may be compressed until it has sufficient elastic force to counterbalance the momentum, and bring to rest the liberated valve and the parts of the valve gear connected therewith.

In order that each steam valve may uncover its port at the proper moment, to admit steam to the cylinder, the adjacent member of the part of the valve gear appertaining to the eccentric, which, in this instance, is the sliding block (g',) is moved back, by the turning of the eccentric by the power of the engine, into such a position that the link (h') can be moved laterally, to place its acting face within the range of motion of the face upon the sliding block, when the latter is again moved to draw the valve along; this movement of the valve gear takes place before the piston is ready to make its stroke from the adjacent end of the cylinder, and the lateral movement of the link is effected by a spring (i''.)

In the example, thus described, the liberation of the valves, whose motions are arrested, is effected by the instrumentality of a cam, and the closing, by the instrumentality of weights; these, however, constitute no part of my present invention, as the form and construction of the valve and valve gear may be varied indefinitely, as well as the means for imparting the closing movement to the valves, without changing, substantially, the method of arresting their movement after liberation takes place.

What I claim as my invention, and desire to secure by letters patent, is—

The combination, substantially as described, of an air-cushion with the liberating valve gear of steam-engines.

In testimony whereof, I have hereunto subscribed my name.

(Signed) GEORGE H. CORLISS.

Witnesses:

HENRY BALDWIN, Jr.

JOHN S. HOLLINGSHEAD.

10 F.

Reissue No. 763.

The United States of America to all to whom these letters patent shall come:

Whereas George H. Corliss, of Providence, Rhode Island, has alleged that he has invented a new and useful improvement in cut-off and working valves of steam engines, (for which letters patent were issued to him, dated March 10th, 1849, the same surrendered and new letters issued to him, dated May 13th, 1851, which last letters having been surrendered by him, the same have been cancelled and new letters ordered to issue to him on six amended specifications,) which he states has not been known or used before his application, has made oath that he is a citizen of the United States; that he does verily believe that he is the original and first inventor or discoverer of the said improvement, and that the same hath not, to the best of his knowledge or belief, been previously known or used: has paid into the treasury of the United States the sum of thirty dollars, and presented a petition to the Commissioner of Patents signifying a desire of obtaining an exclusive property in the said improvement, and praying that a patent may be granted for that purpose:

These are therefore to grant, according to law, to the said George H. Corliss, his heirs, administrators, or assigns, for the term of fourteen years from the tenth day of March, one thousand eight hundred and forty-nine, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improvement, a description whereof is given in the words of the said George H. Corliss, in the schedule hereunto annexed, and is made part of these presents.

In testimony whereof, I have caused these letters to be made patent, and the seal of the Patent Office has been hereunto [L. S.] affixed. Given under my hand, at the city of Washington, this twelfth day of July, in the year of our Lord one thousand eight hundred and fifty-nine, and of the independence of the United States of America the eighty-fourth.

JACOB THOMPSON,
Secretary of the Interior.

Countersigned and sealed with the seal of the Patent Office.

WM. D. BISHOP,
Commissioner of Patents.

11 No. 763.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, George H. Corliss, of the city and county of Providence, in the State of Rhode Island, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the principle or character which distinguishes it from all other things before known; and of the manner of making, constructing, and using the same, reference being had to the accompanying drawings, making part of this specification, in which fig. 2 represents a longitudinal vertical section through an engine embracing my improvements, the parts behind the plane of the section being shown in elevation; fig. 3 represents an elevation of the valves, and of the valve gear of the same; fig. 4 represents a plan thereof; fig. 5 a separate section, representing a link, used in the valve gear; figs. 6 and 7 a plan and a section of an air-cylinder and piston for checking the motion of the valve apparatus. The same letters indicate like parts in all the figures.

The object of my invention is a more efficient regulation of the velocity of the steam-engine, with a more economical employment of steam therein, than has been attained by the methods heretofore adopted; and my invention consists in effecting this object by a new mode of operation, which is embodied in a combination of two sets of apparatus; one of which I call the *regulator*, and the other, a *liberating valve gear*. The former is an instrument, which, when set in motion, changes the relative position of some of its parts, as changes occur in its velocity, and, by virtue of such changes, is capable of communicating motion to other mechanism; the latter is a valve gear which embodies two forces for operating the steam valves; the one for their opening movement, which may be derived from the engine itself; the other for the closing movement, which may be derived from weights or springs or their equivalents; and whilst the arrangement may be such that the reciprocal operations of these two forces may give the proper movements for closing the valves at certain fixed periods of the stroke of the piston, there must be embodied a provi-

sion for effecting the closing of the valves, at variable periods of the stroke, by such a release of that portion of the valve gear actuated by one force, from that actuated by the other force, as will anticipate the time at which the valves would be closed, if their closing was effected by the return movements of the opening mechanism.

A liberating valve gear presents, as I have discovered, peculiar features of adaptation for working in combination with a regulator, as it has the capability, beyond other species of valve gear, of reducing the amount of power required of the regulator in controlling the periods of closing the valves, and also of reducing the range of movement required of the regulator in fulfilling the requirements of regulation; and, though the regulator possesses a very limited amount of available force, within the limits of variation in velocity consistent with proper regulation, yet that force may be so applied to a liberating valve gear, as to be felt at each stroke of the engine, and vary the period of cut-off to correspond with the changes in velocity.

I have represented my invention, in the accompanying drawings, as applied to an engine embodying various other inventions, a more full description of which is given in sundry patents granted to me, bearing even date herewith.

In this engine the steam and the exhaust valves (*l*, *l*,) and (*m*, *m*,) are situated in steam chests (*n*, *o*,) at each extremity of the steam cylinder. Each exhaust valve (*m*) is attached to one extremity of a valve rod, (*p*,) which is fitted, at its opposite extremity, with a sliding head (*q*) that is linked by a connecting rod (*r*) to one arm (*s*) of a bell crank (*t*.) The other arm (*v*) of the bell crank is connected by a rod with a wrist pin (*w*) on the wrist plate (*x*.) The latter is secured to a crank shaft, to which the requisite vibratory motion is imparted by an eccentric, (*a*,) through the intervention of an eccentric rod, and an arm (*y*) secured to the rock shaft, so that, as the eccentric is caused to revolve with the crank shaft, the exhaust valves are drawn open, and are moved back to close their ports by the power of the engine with the peculiarities of movement incident to the employment of the wrist motion. As, however, the wrist motion forms no part of the invention set forth in this specification, a minute description of it herein is deemed unnecessary. In the valve gear, thus far described, each exhaust valve is connected permanently with the eccentric, through the intervention of the wrist plate and its appurtenances; and the exhaust valves are opened and closed wholly by the power of the engine.

The valve gear for operating the steam valves differs from that for the exhaust valves in being constructed in parts, which are separable from each other, so that each valve may be permitted to close, independently of the power of the engine. A part of this valve gear is connected permanently with each valve, and, in the engine I am now describing, the part for each valve consists of a double valve rod (*b'*) upon which a weight (*o'*) is arranged to act, through the intervention of a bent lever of bell crank, (*m'*,) to cause the valve to close its port, whenever the part of the valve gear connected with the valve is separated from the remainder of the valve gear. The other part of

the valve gear consists, in this instance, of two sliding blocks (g', g';) the bell cranks (f', f') having teeth that engage with corresponding teeth in the blocks; the wrist plate (*x*) and its appurtenances; and the eccentric (*a'*) with its appurtenances; the latter, in its revolutions, causing the sliding blocks to traverse to and fro. The part of the valve gear connected permanently with each valve is fitted with a variable link or medium of connection (*h'*,) which is hinged to the valve rod, (*b'*,) and has an acting face (*c*) which can be placed in contact with a corresponding face (*e*) formed upon the adjacent sliding block. When these two faces are in contact, the part of the valve gear connected permanently with the valve is moved along with the remainder, so that the valve is drawn open, and the weight lifted by the power of the engine; the two acting faces (*c*, *e*,) remaining in contact until a separation is made by a lateral movement of the one to the other. Such a lateral movement is effected, in the present example, when steam is to be cut off by means of a cam (*k'*) which is turned by the power of the engine through the intervention of a series of shafts and wheels, the last of which is secured to the crank shaft; and, as in this engine the shank of the link is not within the range of motion of the cam, a projection (*j'*) is secured to the link upon which the cam bears when a separation of the one part of the valve gear from the other, and the consequent liberation of the steam valve with its weight from the opening mechanism takes place, and the valve is then instantly closed by the power of the weight. As the steam valves, in the steam-engine represented, move horizontally, they do not tend to close by their own weight, and are consequently closed by means of the weights (*o'*, *o'*,) arranged as before described. In order to prevent the jar, which would result from the sudden stoppage of the motion of the weights, each cross block (*N*) has a cylindrical socket (*n'*, fig. 7) to contain atmospheric air open towards the steam cylinder, and a piston (*p'*) is secured to the engine frame in such a position that it enters the cylindrical socket, and fitting the same, compresses the air therein as the valve closes to form an elastic cushion to prevent jar. In order that each steam valve may uncover its port at the proper moment to admit steam into the cylinder, the part of the valve gear connected permanently with the eccentric is moved back by the operation of the eccentric, before the commencement of a stroke, a sufficient distance to permit the acting face
12 of the link to be moved laterally by a spring (*i''*) within the range of motion of the opposite acting face of the valve gear, so that when the valve gear connected with the eccentric again moves forward, the two parts of the valve gear are connected by the link, and the valve is drawn open.

In the engine I have represented in the drawings the valves are moved in directions at right angles with the axis of the steam cylinder, and the valve gear is adapted to this arrangement of the valves: when, however, the valves are so arranged that they move parallel with the axis of the cylinder, as in the customary arrangement in slide-valve engines, the rock shaft by which they are operated may,

with advantage, be located in a position different from that described above, and the valve connections must be adapted to this change.

We learn from standard works on the steam-engine that it has long been well known that great advantages in the economy of fuel would accrue from a change in the application of the regulator of steam-engines from the *throttle* valve to the expansion or cut-off valves. And yet, until the date of my invention, the application of the regulator to the *throttle* valve was practically the universal rule in working engines in all parts of the world, if we except a few doubtful instances of isolated engines of very limited capacity—those constructed with a liberating valve gear forming no exception to that rule.

One of the exceptions above referred to is described in "Tredgold's Treatise on the Steam-Engine," at page 283, article 492, and in the explanations of plate XVI of that work, in which plate the engine is exhibited by drawings. Here the regulator is represented as applied to a rotating cam, upon which a puppet or lifting valve was raised, and, after being held up the required length of time, was lowered to its seat. As this cam was designed to govern, by its external form, the periods of opening and closing the valves, it was elongated so as to admit, within its length, all the gradations of form requisite for closing the valve at earlier and later periods of the stroke of the piston, and then it was placed upon an axle in bearings, which admitted of its endwise movement to the extent which was necessary for bringing, as required, the several gradations of form throughout its length, corresponding to the varying periods of closing, within the plane of movement of the valve lever. The range of motion of the regulator was then adapted to the length of movement required by the length of the cam. This device is represented as applied, "by way of experiment," to what is termed a "portable engine," and the valve, operated by it, is shown in the drawings side by side with the *throttle* valve.

Others of the exceptional engines referred to are described in a French publication entitled Armengaud's Publication Industrielle, &c., vol. 5, plate XXXVIII, and vol. 6, plates I and XII, and in the text of those volumes descriptive of those plates, and of the engines therein represented. In these engines also the regulator is applied to a cam, the varying parts of whose surface are made to act upon the valve rods, so as to close the valves at varying periods of the stroke of the piston; but all these plans, under various arrangements of mechanism, embody a common method of operation—the same, substantially, as that in the engine referred to in Tredgold's Treatise.

Another plan is described in a Scotch publication—"The Practical Mechanic and Engineer's Magazine," for April, 1846, pages 165 and 166, vol. 1—consisting of a supplemental valve, placed upon the back of the main steam valve, upon which it rides as the latter is moved to and fro by an eccentric, and the arrangement is such that at certain times, viz:—the varying periods in the stroke of the piston when the steam is to be cut off—the riding valve is held still by the regulator to allow the main valve to slide beneath it, and thus bring the steam port of the main valve under the supplemental valve, and

thereby cut off the flow of steam into the cylinder, the closing movement being determined by the form of the cam or eccentric which actuates the main valve.

The foregoing published methods of regulating the motion of steam-engines are types of classes of arrangements which have long been well known; but in all these the closing of the steam valve through which the regulator operates is dependent upon the form of the cam, by which the opening movement of the valve is effected, and not upon a liberation from the cam to permit the valve to be closed by a weight or spring or other equivalent means, so as to anticipate the time at which the valve would have been closed, under the control of its opening mechanism, if no such liberation had taken place. From these instances it will be seen that the employment of weights and springs, in giving one movement to the valve, while the other is given by a cam, does not, of necessity, involve the use of a liberating valve gear, as they may be used for keeping the valve mechanism in contact with the cam, and thereby keeping the valve in that position relatively to the other parts of the engine indicated by the form of the cam. In the case cited from the Scotch publication the operation of the supplemental valve depends upon the arm held by the regulator as well as upon the cam attached to the crank shaft, which is another instance of the employment of two forces for operating the valve without involving the features of a liberating valve gear.

I wish it to be distinctly understood that the invention which I claim under this patent does not consist in the form of the regulator employed, nor in the form of the valves, nor in the form of the valve gear for opening the valves, nor in the arrangement of devices for liberating the valves from the mechanism by which they are opened. Various forms of liberating valve gear heretofore used in steam-engines may, with good effect, be combined with the regulator so as to control the periods of liberating the steam valves, and thereby embody my invention.

In the form of steam-engine delineated in fig. 2 the periods of liberating the valves may be varied by wedge-formed stops or cams substituted for the helical cams and connected with the slide of the regulator, which in that case should not turn; cam-shaped, or other forms of stops, may be connected with the slide of the regulator by levers, so as to be moved in the plane of motion of the valve mechanism in such directions as to vary the periods of liberating one portion of that mechanism from the other. It is obvious that, by such changes, the form, arrangement, and operation of the mechanism of liberation might be greatly varied, whilst the mode of operation for effecting regulation would remain unchanged.

What I claim as my invention, and desire to secure by letters patent, is—

The method, substantially as described, of regulating the velocity of steam-engines by combining a regulator with a liberating valve gear.

In testimony whereof, I have hereunto subscribed my name.
(Signed) GEORGE H. CORLISS.

Witnesses:
HENRY BALDWIN, Jr.
JOHN S. HOLLINGSHEAD.

13 G.

Reissue No. 780.

The United States of America to all to whom these letters patent shall come:

Whereas George H. Corliss, of Providence, Rhode Island, has alleged that he has invented a new and useful improved cut-off gear, (for which letters patent were issued to him, dated July 29, 1851, which letters having been surrendered by him, the same have been cancelled and new letters ordered to issue to him on an amended specification,) which he states has not been known or used before his application; has made oath that he is a citizen of the United States; that he does verily believe that he is the original and first inventor or discoverer of the said cut-off gear, and that the same hath not, to the best of his knowledge and belief, been previously known or used; has paid into the treasury of the United States the sum of fifteen dollars, and presented a petition to the Commissioner of Patents signifying a desire of obtaining an exclusive property in the said cut-off gear, and praying that a patent may be granted for that purpose:

These are therefore to grant, according to law, to the said George H. Corliss, his heirs, administrators, or assigns, for the term of fourteen years from the twenty-ninth day of July, one thousand eight hundred and fifty-one, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said cut-off gear, a description whereof is given in the words of the said George H. Corliss in the schedule hereunto annexed, and is made a part of these presents.

In testimony whereof, I have caused these letters to be made patent, and the seal of the Patent Office has been hereunto affixed.

Given under my hand, at the city of Washington, this twenty-sixth day of July, in the year of our Lord one thousand eight
[L. S.] hundred and fifty-nine, and of the independence of the United States of America the eighty-fourth.

JACOB THOMPSON,
Secretary of the Interior.

Countersigned and sealed with the seal of the Patent Office.

WM. D. BISHOP,
Commissioner of Patents.

14 No. 780.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, George H. Corliss, of the city and county of Providence, in the State of Rhode Island, have invented certain new and useful improvements in the method of actuating variable cut-off valves of steam-engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings making part of this specification; in which fig. 1 represents a side elevation of a beam engine with my valve gear applied thereto; fig. 2 and 3 are fragmentary side elevations of the steam cylinder and valve gear; and fig. 4 is a section of one of the valve chests and the parts adjacent thereto.

In my said invention the valves are connected with and operated by rocking levers or their equivalents by any suitable mode of connection, and these levers are operated in one direction, during the closing of the valves, either by their gravity, by weights connected therewith, or any other suitable means, to insure the rapid closing of the ports; and in the opposite direction, to open the valves by means of two shoulders, each mounted upon the surface of a spring bar or its equivalent, the latter having a positive longitudinal motion derived from an eccentric or other suitable part of the engine. Each of said shoulders, with the portion of the spring bar to which it is attached, is free to move towards and from the axis of the rocking lever which it actuates, to admit of adjustment to liberate the valve at any required period of the stroke of the piston.

This part of my invention consists in combining with the levers that operate the valves, the shoulders on the spring bars, the said shoulders being borne towards the axis of the levers by the force of gravity or springs.

And my invention also consists in regulating the periods of closing the valves, by means of stops or gauge bars, which are adjustable by a governor or other means, when combined with the shoulders on the spring bars to regulate their position and thereby determine the periods of liberating the valves, that they may be closed by gravity or other equivalent means, whilst the periods of opening the valves remain unchanged.

In the accompanying drawings (*a*,) fig. 4, represents a slide valve connected by an arm (*c'*,) with an arbor (*d*,) having an arm, (*e*,) fig. 1, from which a weight (*f*) is suspended to close the valve when the rocking lever (*c*) is liberated. Within the extremities of the rocking levers for the two valves are bars, (*g*, *g*,) which receive a positive longitudinal motion from a plate (*x*,) which is actuated by an eccentric (*i*,) and on each of these bars a shoulder (*s*) is raised which comes in contact with the extremity of the rocking lever (*c*) when the latter is to be moved to open the valve; and as each bar is hinged at

one end to the plate (*x*,) the other end is free to move transversely to the axis of the cylinder, and is borne outward by a spring (*l*) towards a stop or gauge bar (*m*,) fitted to slide in the standard (*o*,) where it may be held at any point of adjustment by means of a wedge-formed block (*u*.)

It will be seen, by inspection of the drawings, that as the spring bars are moved longitudinally in contact with the gauge bars, the outer edges of the shoulders, which actuate the rocking levers, are moved in lines which cross the lines described by the extremities of the rocking levers, and the shoulders are thus drawn out of the path of movement of the rocking levers; and as they are made to traverse in different lines of movement, corresponding with every change in the position of the gauge bars, the periods at which the liberation of the valves will be effected will be correspondingly changed.

The blocks (*u*, *u*,) for the two valves are secured to a sliding rod (*y*,) and the latter may be connected with the governor at (*r'*,) to determine by the velocity of the engine the position of the gauge bars, and hence determine the distance to which the shoulders on the spring bars may be forced outward by the springs, which will determine the period of closing the valves; and when this valve apparatus is thus combined with the governor, the mode of regulation patented by me, March 10, 1849, will be embodied. In the present instance the sliding rod (*y*) is represented as moved through the intervention of a rack (*n*) and worm (*p*.) This is intended for hand adjustment. The rack and worm are dispensed with when the governor is applied.

Now, it will be seen that, by the motion of the spring bars, the two shoulders always act upon the rocking levers to open the valves at the same period of the stroke of the piston; but the periods when the shoulders shall liberate the rocking levers to permit the valves to be closed depends upon the lateral movement of the shoulders in the direction of the gauge bars; that is, the more the lateral movement of the shoulders on the spring bars is restricted by the gauge bars, the sooner the rocking levers will be liberated, and vice versa; and, therefore, by simply varying the position of the gauge bars, the periods of closing the valves can be changed, whilst the period of opening them remains the same.

I do not wish to be understood as limiting myself to the special construction and arrangement of the several parts, but to cover all merely formal variations.

What I claim as my invention, and desire to secure by letters patent, is—

Combining with the rocking levers, or their equivalents, for operating the valves, the shoulders on the spring bars, or their equivalents, substantially as described and for the purpose specified.

And I also claim, in combination with the shoulders on the spring bars that operate the rocking levers, substantially as described, the employment of the gauge bars, or any equivalent therefor, to regulate the periods of closing the valves, whether the said gauge bars be regulated by a governor or by other means as set forth.

In testimony whereof, I have hereunto subscribed my name.
(Signed) GEORGE H. CORLISS.

Witnesses:
HENRY BALDWIN, Jr.
JOHN S. HOLLINGSHEAD.

DISTRICT OF CONNECTICUT,
Circuit Court Clerk's Office, ss:

Filed 10th November, 1859.
Attest: ALFRED BLACKMAN, *Clerk.*

15 Circuit court of the United States district of Connecticut.

GEO. H. CORLISS
vs.
WHEELER & WILSON MANF'G CO. and NATHANIEL WHEELER. } In equity.

To the honorable the justices of the circuit court of the United States for the second circuit within and for the district of Connecticut, sitting in equity:

The answer of the Wheeler & Wilson Manufacturing Company, and the answer of Nathaniel Wheeler, of Bridgeport, in the district of Connecticut, a member of and the president of said company, to the bill of complaint of George H. Corliss, of Providence, in the district of Rhode Island.

And thereupon the said defendant corporation and the said defendant Nathaniel Wheeler, saving and reserving to themselves all advantage and benefit of exception to the said bill of complaint, for answer thereunto, or to so much and to such parts thereof as they are advised are material or necessary for them to make answer unto, answering, say:

That they have been informed, and admit it to be true, that prior to the 10th day of March, A. D. 1849 the said George H. Corliss did make application to the Commissioner of Patents for letters patent of the United States to be issued to him for an alleged improvement in "cut-off and working the valves of steam-engines," and that such proceedings were had on such application; that afterwards, to wit, on the 10th day of March, 1849, letters patent of the United States were in fact issued to the said Corliss, to which said letters patent, and to the drawings and schedule making a part of the same, these defendants crave leave to refer; and they have, for greater convenience and certainty, annexed a copy of the same hereto, marked A, and do make the same a part of this their answer.

And these defendants further admit that afterwards, to wit, on or about the time named in the complainant's said bill of complaint, the said letters patent last above mentioned were by the said Corliss surrendered and canceled, and new letters patent, on an amended specification, were afterwards, to wit, on the 13th day of May, 1851, issued to the said Corliss, for the remainder of the term of fourteen

years, dating from the 10th day of March, 1849; to which said reissue letters patent, and to the drawings and schedule making a part of the same, these defendants crave leave to refer; and they have, for greater convenience and certainty, annexed a copy of the same, marked B, and do make the same a part of this their answer.

And these defendants, further answering, say that they have been informed, and believe it to be true, that at or about the time named in the complainant's said bill of complaint the said reissue letters patent last above referred to were surrendered and cancelled, and that on the 12th day of July, 1859, six several new letters patent, each on a distinct specification, were issued to the said Corliss as charged in said bill. Nevertheless, these defendants, for greater certainty, crave leave to refer to the same when they shall be produced, they denying that said several reissue patent are for the same invention as that for which letters patent were granted as aforesaid to the said Corliss, dated March 10, 1849, or for the same invention for which reissue letters patent, dated May 13, 1851, and above referred to, were subsequently granted.

And these defendants, further answering, say that they are informed and believe that the said Corliss has not been, since the issuing of the several reissue letters patent set forth in said bill of complaint, in the exclusive possession and enjoyment of the same, and each of
16 them, as charged in said bill; but, on the contrary, they aver that at no time since the date of the last of said reissue patents, nor at any time previously while the original letters patent or any reissue thereof were in force, has the said Corliss been so in the exclusive possession and enjoyment of the improvements described in said patents. And they further aver that each of said pretended inventions and improvements, as described and claimed in said several patents, has been, at divers times since the 10th day of March, 1849, put into public and open use, to the knowledge of the said Corliss, and under a claim of right on the part of those so making use of said pretended improvements to continue the same, and without any attempt on the part of the said Corliss to interfere with or restrain such use.

And these defendants, further answering, say that they are informed and believe, and accordingly state the fact so to be, that at the June term of the circuit court of the United States for the district of Rhode Island, holden at Newport, in said district, before his honor Mr. Justice Pitman, A. D. 1852, the said George H. Corliss impleaded one John Gorham 2d in an action on the case, wherein he declared against the said Gorham 2d for a violation of the exclusive privilege alleged to have been granted to him by the letters patent set forth in this bill of complaint, bearing date March 10, 1849, which were alleged to have been reissued on a pretendedly amended specification, such reissue bearing date March 13, 1851, the same being for the same pretended improvement in cut-off and working the valves of steam-engines, as is set forth in this bill of complaint; and the said defendants in said action admitted that they were using an engine having the description of liberating valve gear commonly known as the

Sickels valve gear, and that such gear was combined with one of the well-known varieties of regulators for steam-engines known as the Pitcher hydraulic regulator. Nevertheless, they denied that they were infringing upon the patent or employing the invention of the said Corliss; and, furthermore, they put in issue the novelty of the said pretended invention of the said Corliss. And the jury to whom said cause was committed returned a verdict for the defendants. All of which will more fully appear from the record of said court, a copy of which is, for greater certainty and convenience, hereunto annexed, marked C, and made a part of this answer.

And these defendants are further informed and believe that afterwards, to wit, at the term of said court, the application of said Corliss for a new trial in said case was denied, with costs.

And these defendants, further answering, say that they are informed and believe, and accordingly state the fact so to be, that the said George H. Corliss, at the June term of the circuit court of the United States for the district of Rhode Island, A. D. 1856, commenced an action in the case against Simeon W. Dexter and Daniel S. Dexter, wherein he declared against the said defendants for a violation of the exclusive privileges alleged to have been granted to him by the said letters patent and reissue thereof last above stated; and the said Simeon W. Dexter and Daniel S. Dexter, who, as these defendants are informed and believe, were using a steam-engine built according to the specification attached to the letters patent granted to one Noble T. Greene, hereinafter to *to* be more particularly referred to, did, in answer to said action, not only deny that the machine by them used was any infringement upon the pretended exclusive grant to the said Corliss, but also put in issue the novelty of the invention as described in said letters patent. And afterwards, to wit, at the June term of the same court, holden at Newport, said cause came on to be tried before his honor Mr. Justice Pitman; and the same was committed to a jury, who, after deliberation, reported to the court that they were unable to agree upon a verdict, and were thereupon discharged.

And these defendants are further informed and believe, and accordingly state the fact so to be, that the same action last above referred to again came on to be tried, upon the same issues as above stated, at the November term of the same court, A. D. 1857, holden at Providence, before his honor Mr. Justice Pitman, and was com-
17 mitted to a *second* jury, who, after due deliberation, reported to the court that they were unable to agree upon a verdict, and were thereupon discharged.

And these defendants are further informed and believe, and accordingly state the fact so to be, that the same action last above referred to again came on to be tried upon the same issues as above stated, at the June term of the same court, A. D. 1858, holden at Newport before their honors Justices Clifford and Pitman, and was committed to a *third* jury, who, after due deliberation, reported to the court that they were unable to agree upon a verdict, and were thereupon discharged.

And these defendants are further informed and believe, and ac-

cordingly state the fact so to be, that the same action last above referred to again came on to be tried upon the same issues as above stated, at the November term of the same court, A. D. 1858, before his honor Mr. Justice Pitman, and was committed to a *fourth* jury, who, after due deliberation, reported to the court that they were unable to agree upon a verdict, and they were accordingly discharged.

And these defendants are further informed and believe, and accordingly state the fact so to be, that at the June term of the same court, A. D. 1859, the said Corliss discontinued his aforesaid action against the said Samuel W. and Daniel S. Dexter, with costs. Copies of the record of each of said trials are hereunto annexed, marked D, E, F, G, and made a part of this answer.

And these defendants are further informed and believe, and accordingly state the fact so to be, that at the June term of the circuit court of the United States for the district of Rhode Island, A. D. 1856, the said George H. Corliss commenced an action on the case against one Lewis P. Mead, wherein he declared against the said Mead for an alleged violation of the same letters patent upon which suit was brought against the said Simeon W. and Daniel S. Dexter, as above particularly set forth and described, and these defendants are informed that the said Mead was using an engine having a liberating valve gear in combination with a fly-ball regulator for the purpose of controlling the speed of the engine under varying loads, and that he did, in answer to said action, put in issue the fact of infringement as well as the novelty of the said Corliss' pretended invention; and further, these defendants are informed and believe that the said Corliss never called on said case for trial, but allowed the same to be continued from term to term, until the June term of said court, A. D. 1859, when the said Corliss discontinued said action with costs, all of which will more fully appear from the record of said action, a copy of which is hereunto annexed, marked H, and made a part of this answer.

And these defendants, further answering, say that they are informed and believe, and therefore state the fact so to be, that in no single instance has the original patent granted to said Corliss, March 10th, 1849, or any reissue of the same, been sustained, or its validity been established by the verdict of any jury, upon any one of the several trials that have been had, or by the judgment of any court of law.

And these defendants, further answering, say that the Wheeler & Wilson Manufacturing Company, since the issuing of the last one of the reissue patents set forth in said bill, and before the date of the filing of the bill of complaint, did use and operate two steam-engines constructed by the Pacific Iron Works, at Bridgeport, in that district—one of which was fourteen inches diameter of cylinder and three and a half feet stroke of piston, and the other was ten inches diameter of cylinder and three feet stroke of piston—and said engines contained and embodied the improvements invented by one Noble T. Greene,
and for which he then and now holds letters patent of the
18 United States, granted to him in due form of law on the 13th
day of March, A. D. 1855; and that said machines in their

structure and mode of operation were, and the engines now used by them in place of those last spoken of are, substantially different from the several pretended inventions and improvements as described and claimed in the several reissue patents of said Corliss set forth in said bill of complaint, except as hereinafter particularly admitted.

And the defendants further say that they were, during the whole of the time that said engines had been used, licensed and fully authorized by the said Noble T. Greene to use the said machines so constructed in accordance with the said letters patent to him granted as aforesaid, a copy of which said letters patent are hereunto annexed, marked I, and made a part of this answer.

And these defendants further say that the said engines by them, as aforesaid, admitted to have been used by them before the exhibition of the complainant's said bill of complaint, as well as the engines now used by them, operate essentially different from the engine, or any modification thereof, described or indicated in the several reissue specifications of the said Corliss—that is to say:

The valves, which are four in number, (two for the induction and two for the eduction of the steam,) are of the well known variety called "flat side valves." The two exhaust valves (one located at each end of the cylinder) are connected with the eccentric on the main shaft by means of a rod, and are worked in the ordinary way. The two steam valves (one located at each end of the cylinder) are each connected by shackle-rods with the upper arms of the rocking levers mounted on arbors, which arbors are provided with arms, to which weights are suspended sufficiently heavy to close the valves when the rocking levers are not in contact with the opening mechanism. Below the two rocking levers is placed a bar, mounted in standards, which receives a positive longitudinal motion from a second eccentric on the main shaft, and which motion (leaving out allusion to the provision for overcoming the lap of the valve over its port and the lead which, as these defendants are advised, is not material to the questions at issue) is coincident with the motion of the piston of the engine; that is to say, as the piston travels from one end of the cylinder to the other, the sliding bar travels from one extreme of its range of motion to the other. On this sliding bar, and at right angles to its length, are mounted two tappets, each of which is formed with a projecting shoulder to determine the limit of its motion downward, and each of which is forced upward by the tension of a spring placed beneath it against the lower edge of a gauge bar placed parallel with the line of motion of the tappet bar. In the engines used by these defendants subsequent to the date of said several reissue patents, when the said tappets were at their highest point of elevation and the engine put in motion, one of the tappets would come in contact with the inner face of one of the rocking levers, and, after opening the valve, invariably pass beyond the range of motion of the rocking lever, when the valve would suddenly close by the action of the weight suspended to the arm, and in no instance was it ever controlled in its return to its seat by any of the parts of the valve mechanism.

And these defendants further say that in the practical operation of

their said machines, the hight at which either tappet, at the moment of contact with its corresponding rocking lever, projected above the face of the tappet bar, determined the length of time for any given speed of the engine during which the corresponding valve remained open, the closing of the valve not being effected by any cam-stop, or other equivalent instrument, interposed for the purpose of liberating the valve from its opening mechanism.

And these defendants, further answering, say that in the engines above referred to, as used by them, the regulator was attached to, and combined with, the gauge bar above spoken of, and by its action in simply elevating or depressing the gauge bar, thereby determined how much of the face of the tappet should come in contact with
19 the rocking lever; one of the distinctive features of this method of regulation being that the gauge bar, operated by the regulator, determined, before the stroke commenced and while the tappets were free to be moved, the hight of the tappets above the bar, and, in effect, gauged or measured out to the engine the *quantum* of steam that it was permitted to receive to enable the piston to complete the next ensuing stroke.

And these defendants, further answering, state, from their knowledge and belief, that the two engines, so by them used before the date of said several reissue patents, and before the filing of this bill of complaint, constructed upon the plan invented and patented by said Noble T. Greene, do effect a saving of fuel over engines constructed upon plans before known and used; and also over engines constructed upon the plan patented by said Corliss, and that such saving is about fifteen per cent. over the best engines constructed by said Corliss, the consumption of coal per horse-power, for each hour of work, being about *thirty-six ounces.*

As to reissue patent No. 759.

And these defendants, further answering, say particularly in reference to the reissue patent of the said Corliss, numbered 759, and set forth and attached to said bill of complaint—

That the pretended invention, as described and claimed by said Corliss in said reissue patent, is not the same, or any part of the same, invention alleged to have been made by the said Corliss, and sought to be secured by him by the original letters patent from the United States, granted March 10, 1849, for an improvement in cut-off and working the valves of steam-engines, but is for an entirely different and distinct invention; and these defendants, therefore, humbly submit that said reissue patent 759 is in law inoperative and invalid.

And, further, these defendants aver the fact to be that the use by the said Corliss of a liberating valve gear and common slide valves, in combination, was not considered or claimed by the said Corliss at the date of his said original patent to constitute any invention or to exhibit any patentable novelty; and such being the fact, these defendants humbly submit unto this honorable court that the thirteenth section of the act of Congress entitled "An act to promote the pro-

gress of the useful arts." (approved July 4, 1836,) does not authorize the grant of a reissue patent for an invention *not known or believed to have been made*, or attempted to be secured, at the time of the application for and grant of the original letters patent.

And these defendants, further answering, say that the said Corliss, at no time between the date of his application for said original patent for improvement in cut-off, &c., to wit, twenty-sixth day of August, 1848, and the date of said reissue patents, to wit, July 12th, 1859, ever pretended or claimed that he was the first and original inventor of the *alleged* improvement described in said reissue; that the patent of said Corliss was, during the most of that time in controversy—that is to say, for a period of seven years, during which the said Corliss or his licensees were defendants, and for a further period of three years, during which the said Corliss was a plaintiff against some of the licensees of said Noble T. Greene, as well as against the owners of engines having puppet valves, and at none of the many trials at law or in equity which were had during all that time was any such claim put forth. And, further, that the said Corliss has, as these defendants are informed and believe, been personally knowing to the fact that a great number of engines, other than those built by the said Corliss or his licensees, have been in operation for many years in various parts of the United States, (and among that number the two engines admitted to have been used by these defendants,) some of which had a liberating valve gear of some one of the many varieties, in combination with a slide valve, which overlapped its port, and others of which had the peculiar valve gear of the said N. T. Greene; yet the said Corliss, although he claimed some of said engines to be an infringement upon the mode of regulation alleged to have been invented by him, never asserted that such combination, last above spoken of, was any invention or patentable novelty belonging to him; wherefore these defendants respectfully submit to this honorable court that the said Corliss, by his said conduct in the premises, has intentionally abandoned his invention to the public, or that he is estopped by his said acts now to assert any title thereto.

And these defendants, further answering, say that before the application of the said Corliss for his original letters patent, a liberating valve gear, "that is to say, a valve gear which embodies two forces for operating the steam valves" was in public use, and was described in letters patent of the United States granted to Frederick E. Sickles, dated May 20, 1842, which said liberating valve gear was, in its principle and mode of operation, substantially identical with that described by the said Corliss in the reissue patent above mentioned; reference to said letters patent being had for all matters therein contained, a copy whereof is hereunto annexed, marked I, and made a part of this answer.

And these defendants, further answering, say that said liberating valve gear was used by the said Sickles in the cities of New York, Baltimore, Washington, and elsewhere, to operate one of the varieties of steam valves, known as puppet valves, and the fact was, as

these defendants are informed and believe, well known to the said Corliss. And further, these defendants say that, long before the date of the application of said Corliss, slide valves, identical in principle and construction with the valves described by said Corliss—that is to say, valves which slide parallel to their seats, and overlap their ports when their ports are closed—were well known and in common use, and described in every elementary treatise on the steam-engine—the one or the other kind of said valves being used as the judgment of the engineer indicated, they being recognized among mechanics and engineers as well known equivalents for each other. And further, that the public were informed by a printed publication, published by the said Frederick E. Sickles, before referred to, and one Truman Cook, which was widely distributed, dated ——, 1844, that the liberating valve gear of the said Sickles, above spoken of, was adapted to operate slide valves. A copy of said publication is hereunto annexed, marked J, and made a part of this answer. Wherefore these defendants humbly submit unto your honors that the application of a liberating valve gear of the character described by said Corliss, to valves which are moved parallel to their seats and continue their closing motion after their ports are closed, and commence their opening motion before their ports open, does not exhibit invention, and is only the application of a well known apparatus for operating valves of steam-engines to a well known equivalent for the variety of valves shown in the drawings and descriptions attached to the patent of said Sickles, before referred to.

And these defendants are informed and believe, and they intend to prove, that the said Corliss was not the original and first inventor of the thing by him in said reissue patent, numbered 759, described and claimed as new; but that the same was known to and invented by Frederick E. Sickels, of the city, county, and State of New York, and is shown and described in the letters patent of the United States granted to him September 19, 1845, numbered 4201, and in the drawings and model filed in the Patent Office, belonging to his patent of that date; a copy of said letters patent, granted to said Sickels, is hereunto annexed, marked K; and, also, is more fully shown and described in six several reissued letters patent for the same invention, duly granted to the said Sickles, bearing date on or about February 21, 1860, to which reference is to be had, copies of the same being hereunto annexed and made a part of this answer, marked, respectively, M, N, O, P, Q, R.

As to reissue patent No. 760.

And these defendants, further answering, say that on one of the engines, admitted to have been used by them, the fall of the weights which caused the valves to cover the port was arrested by an air-cushion not substantially different from that shown in the drawings attached to the reissue patent above referred to; but that the fall of the weights attached to the valves of the other of said engines was not arrested by any such contrivance, but was brought to a state of

rest by coming in contact with a cross beam bolted to the engine frame.

21 And these defendants, further answering, say that they are informed and believe that, long before the pretended invention of said Corliss, a means for preventing the injurious consequences resulting to the engine from the too sudden closing of the steam valves was described in the letters patent of the United States granted to Frederick E. Sickels, May 20, 1842, and before referred to, and made a part of this bill of complaint, in combination with a liberating valve gear. And, also, that a cylinder and piston with an air vent in the side of the cylinder to permit the free escape of the air until the vent was closed by the piston, identical with that described by the said Corliss, was known and used for the purposes for which an elastic cushion is useful, long before the date of said Corliss's pretended invention, and is described and shown in the specifications, drawings, and model appertaining to the letters patent of the United States granted to Alva B. Taylor, dated April 13, 1846, and was applied and used by the said Taylor for diminishing the effects of concussion in various ways in the city of New York, where the said Taylor now resides, long anterior to the pretended invention on the part of the said Corliss; whereupon these defendants submit that the use of an air-cushion of the kind described in said reissue patent, in combination with the liberating valve gear of steam-engines, does not exhibit invention—the said air-cushion, in the combination claimed by said Corliss, being a known equivalent for the water-cushion described in the patent of Sickles, in the same combination, and the mere substitution of the one kind of cushion for the other, did not require the exercise of invention.

And these defendants, further answering, say that they are informed and believe that the said Corliss was not the first inventor or discoverer of the thing by him patented, or of a substantial and material part thereof, claimed as new; but that the same, or a substantial and material part of the same, was known and used at the cities of Baltimore, Washington, New York, Providence, and Philadelphia, by the persons whose names and places of residence are hereinafter next mentioned:

Frederick E. Sickles, of the city of New York.
Baldwin Keach, Wilmington, Delaware.
C. Reeder, Baltimore, Maryland.
Isaac P. Morris, Philadelphia, Pennsylvania.
Noble T. Greene, Providence, Rhode Island.
Gideon G. Hicks, Providence, Rhode Island.
Robert L. Thurston, Providence, Rhode Island.
Henry W. Gardner, Providence, Rhode Island.
George Birbeck, jr., New York city.
Peter Hogg, New York city.
Cornelius H. Delamater, New York city.
Robert Robinson, New York city.
Phineas Bennett, New York city.
Livingston S. Bartholomew, New York city.

Ezekiel Williams, New York city.
Thomas Bartholomew, New York city.
William A. Lightall, New York city.

And these defendants, further answering, say that the pretended invention of said Corliss, as described and claimed in said reissue patent, is not the same, or any part of the same invention alleged to have been made by the said Corliss, and sought to be secured by him by the original letters patent from the United States, granted March 10, 1849, for an improvement in cut-off and working the valves of steam-engines, but is for an entirely different and distinct invention; and these defendants, therefore humbly submit that said reissue patent 760 is in law inoperative and invalid.

And, further, these defendants aver the fact to be that the use of an air-cushion, in combination with a liberating valve gear, was not considered or claimed by the said Corliss at the dateof his said original patent to constitute any invention, or to exhibit any pat-
22 entable novelty; and such being the fact, these defendants humbly submit unto this honorable court that the thirteenth section of the act of Congress entitled "An act," &c., approved July 4, 1836, does not authorize the grant of a reissue patent for an invention not known or believed to have been made, or attempted to be secured, at the time of the application for and grant of the original letters patent.

As to reissue patent No. 763.

And these defendants, further answering, say that the engines admitted to have been used by them did not, neither do the engines which they are now using, embody the method of regulation substantially as described in the reissue patent of the said Corliss, numbered 763; and they deny that they are infringing the rights alleged to be secured to the said Corliss thereby, as they understand the true scope, tenor, and legal effect of said patent; that is to say, the pretended invention of the said Corliss consists solely in the application of a regulator to a stop or cam, whose function is equivalent to that of the adjustable sliding piece, I, described in the letters patent above referred to, granted to Frederick E. Sickels, dated May 20th, 1842; the cut-off of the steam, in its passage into the engine, being effected in the respective machines, shown and described in the respective drawings and specifications of said Sickels and of said Corliss, in substantially the same manner, and the difference between the two, in respect to the mode of regulation, consisting in the attachment, by the said Corliss, of the regulator to the instrument which effects the disconnection of the valve gear from the valves, and thereby varying the periods of the liberation of the valves according to the speed of the engine; while, in the machine of the said Sickels, the corresponding instrument to effect the detachment of the valve gear from the valves was shifted to different positions by the hand of the engineer.

And, further, these defendants say that in the engine described in said reissue patent, as well as in all the modifications of structure to

which his said principle in said patent is, by the complainant, claimed to be applicable, the distinguishing characteristic is the interposition, at variable periods, to be determined by the governor, of some instrument like the helical cam described, or an equivalent substitute therefor, whose function must be to effect a separation between the steam valves and their actuating mechanism; and unless such instrument for such purpose be interposed, the valves and their actuating mechanism will continue to be connected, and will be operated, in every particular, like the exhaust valves.

And these defendants deny that the principle on which the velocity of the engine is regulated in the machines admitted to have been used by them is the same, or substantially the same, as that described and claimed by the said Corliss; but that, on the contrary, the machines so by them used differed in principle and mode of operation from that described by the said Corliss in the following essential and substantial respect:

The valve gear in said engines was of a peculiar character, analogous, in its general mode of operation, to the valve gear described in the treatise of Tredgold on the Steam-Engine, and in the *Publications Industrielles*, referred to in said reissue patent of the said Corliss, as anterior to his alleged invention, but totally unlike the valve gear described or suggested by the said Corliss. The sliding bar upon which the tappetts were mounted, as more fully described in that part of these defendants' answer which particularly relates to complainant's reissue patent No. 759, and to which, in this connection, reference may be had, with the same effect as if here repeated, was so operated that it travelled coincidently with the piston, and each tappett was, in consequence, carried beyond the range of motion of the rocking lever, with which in its path of travel it came in contact, and thereby, and not by the agency of any third agent, as a cam, a stop, a wedge, or other equivalent instrument, the valve was permitted to cover its port, it being essentially necessary to the practical operation of the machine that the valve should not be controlled in closing, under any circumstances, by the return movement of the valve gear.

23 And, further, these defendants say that the mode of operation above described was not in any respect varied by the application of the regulator to determine the hight of the tappets, but that the action of the several parts described relatively to each other continued the same. And these defendants say that the differences aforesaid are substantial and material, as well in the mechanical devices used as in the manner in which they are combined and arranged, and in their mode of operation, and in the result and effect thereby produced.

And these defendants, further answering, say that the mode of operation of the steam-engine described in "Tredgold's Treatise on the Steam-Engine," and the mode of operation of the machine described in the French publication entitled *Publications Industrielles*, cannot be distinguished from the mode of operation of the machine of said Corliss by any such difference in principle as that which is pretended

and put forth in said reissue patent No. 763 in the words following: "The foregoing published methods of regulating the motion of steam-engines are types of classes of arrangements which have long been well known. But in all these the closing of the steam valve, through which the regulator operates, is dependent upon the form of the cam, by which the opening movement of the valve is effected, and not upon a liberation from the cam, to permit the valve to be closed by a weight or spring, or other equivalent means, so as to anticipate the time at which the valve would have been closed, under the control of its opening mechanism, if no such liberation had taken place."

But, on the contrary, these defendants say the valve gear used in both of said engines referred to in said reissue patents, as described in said publications anterior to the supposed discovery of the said Corliss, is a liberating valve gear, according to the sense in which the said Corliss has defined that term in said reissue patent—that is to say, it "embodies two forces for operating the steam valves: the one for their opening movement, which may be derived from the engine itself; the other for the closing movement, which may be derived from weights or springs, or their equivalents;" and these defendants aver that in fact the engines so in said publications represented operated, and in said drawing are shown to operate, in such a manner that the valves, in closing, anticipated the time at which they would have been closed had they remained under the control of the operating mechanism.

And these defendants, further answering, say that the supposed invention of the said Corliss, and a substantial and material part thereof claimed as new, was, anterior to the supposed discovery thereof by the said Corliss, described in the following public works:

In a work entitled "*Traite des Machines a vapeur, par C. E. Jullien. Section seconde, Constitution des Machines a vapeur:*" published in Paris, France, A. D. 1847. Plates accompanying the same, 21, 22, 23, text page 220. Also, plate 33, text page 234.

And also in a public work entitled "*Publications des Industrielles des Machines outeils et appareils, par M. Armengaude, jr.*" Vol. 5th of plates, plate XXXVIII. Also, Vol. 6 of plates, plates I and XII, text accompanying the same, page 170; commencing "*Pour la distribution,*" &c.; published at Paris, France, 1847.

And also in a public work commonly entitled "Tredgold on the Steam-Engine," being a treatise on "*The Steam-Engine, its invention and progressive improvements. An investigation of its principles and its application to navigation, manufactures, and railways,* &c. By Thomas Tredgold, civil engineer, &c." New edition, 2 vols. quarto. London, 1838. Plate XV, pages 262–343, §547.

And also a regulator, in combination with another variety of liberating valve gear, is shown and described at plate IX, page 227, §483, and at plate LXXXIV, page 265, §555.

And also in a public work entitled "*Popular Lectures on Science and Art, delivered in the principal cities and towns of the United States.* By Dionysius Lardner. Vol. II. Greeley & M'Elrath, New York, 1846." Pages 477, 478, 479.

And also in a public work entitled "*The Steam-Engine explained and illustrated, with an account of its invention and progressive improvement and its application to navigation and railways, including a memoir of Watt.* By Dionysius Lardner. London, England, 1840." Page 234.

And also in a public work entitled "*The Practical Mechanic.* London, England, 1846." Article *Exhaustion Valves*, pages 165, 168, 189–192, 245–273, 301–305.

And also a regulator in combination with a liberating valve gear, "so as to cause the steam to pass freely from the boiler, to act upon the piston with its full pressure, during a longer or shorter period or portion of each respective stroke, to the extent which may be necessary to maintain the required equable movement of the steam-engine, instead of wasting ineffectually the force of the steam by choking its passage through the throttle valve," is fully shown and described in the *letters patent granted to Zachariah Allen, of Providence, R. I., dated March* 28, 1834.

24 *As to reissue patent No.* 780.

And as to the above reissue patent, these defendants, further answering, say that they are informed and believe that, although the original patent of the said Corliss was granted to him on the 29th day of July, 1851, a copy of which is hereunto annexed, marked L, and although the two machines of these defendants, before admitted to have been used by them, were in operation after the —— day of ———, A. D. 1855; and although many machines identical in their construction and mode of operation with those used by these defendants were put up, in various parts of the country, by the said Noble T. Greene, to the knowledge of the said Corliss, yet the said Corliss never before claimed that the machines of the said defendants, or any machine in use similar to them, was an infringement upon any invention by him made and described in said patent.

And these defendants, further answering, say that they deny that they were infringing the right secured to the said George H. Corliss by the reissue letters patent last aforesaid, by the use of the two machines by them admitted to have been used. That the construction and mode of operation of said machines is specifically set forth and described in that part of these defendants' answer, which relates particularly to the reissue patents numbered 759 and 763, which is to be referred to with the same effect as if at large repeated herein, while the principle and mode of operation of the machine described and claimed in said reissue patent of the said Corliss, is substantially and materially different therefrom in these essential respects:

1st. No cut-off of the steam is effected unless the stop, *m*, is so adjusted that the bars, *g g*, shall impinge against it during the first half stroke of the piston.

2d. No cut-off of the steam can be effected, even within these limits, unless the motion of the bars, *g g*, is so modified by the action of

the wrist plate, *x*, that a lateral motion is imparted to their extremities, which take hold of the rocker arms of the valves.

3d. The function of the stop, *m*, is the same as that of the helical cam described in the reissue patents 759, 763, attached to said bill of complaint—the mode of operation to effect a detachment of the valve gear from the valve differing in this, that while the helical cam is the active agent to force asunder the parts, the stop, *m*, is a passive instrument or stationary fulcrum, against which the valve connecting rod, *g*, is made to impinge, and thus a lever of the first order being constructed, the bond of union between the valve gear and the valve is pried asunder.

4th. The depth of engagement of the shoulders on the spring bars with the rocking levers is not determined by the stop, *m*, before the piston commences its stroke.

5th. Unless the stop, *m*, is placed in such a position that the connecting rods will, during the first half stroke of the piston, come in contact with it as a fulcrum point, the return of the valves to their seats will be controlled by the movement of the valve gear.

And these defendants, further answering, say that they are informed and believe, and therefore state the fact so to be, that, anterior to the supposed invention of the said Corliss, the said invention, or a substantial and material part thereof claimed as new, was described in letters patent granted to Frederick E. Sickels, dated May 20, 1842, a copy whereof has already been made a part of this answer.

And these defendants further say that they are informed and believe that William B. Sickels, Robert L. Thurston, Henry W. Gardner, and Gideon G. Hicks filed their bill in equity in the circuit court of the United States for the southern district of New York,
25 against David L. Youngs and Stephen Cutter, on the 18th of March, 1853, for an infringement of the letters patent last aforesaid stated as granted to the said Frederick E. Sickels, the machine used by them being substantially the same in its construction and mode of operation as the machine described and claimed in said reissue patent numbered 780. And pending the decision of the questions raised by said bill, and the answer thereto, the following issues were, upon the order of the court, tried by a jury at the city of New York:

1st. Whether or not the construction, arrangement, and combination of the apparatus used by the defendants for the more readily cutting off steam, in working the steam-engine, as charged by complainants in their bill, are substantially identical with the construction, arrangement, or combination of the apparatus described in, and claimed by, the complainants, under the patent granted to F. Sickels 20th May, 1842, for the more readily cutting off steam in working the steam engine. And

2d. Whether or not the construction and arrangement of the apparatus for preventing the slamming of the valve in closing, used by the defendants, as charged in the bill, are substantially identical with the apparatus described in, and claimed by, the complainants, under the aforesaid patents.

And these defendants are informed that said issues having been submitted to a jury, a verdict was rendered in favor of the patent of said Sickels, thereby, as these defendants are advised, in effect, finding that the two machines compared, to wit, the machine of the said Corliss and the machine of the said Sickels, as shown and described in their respective patents, were, as mechanical contrivances in respect to the combination of devices to effect the cut-off of the steam, substantially identical in principal and mode of operation.

And these defendants are informed and believe that the said Noble T. Greene did, in the year 1845, conceive the method of cutting off steam and regulating the steam-engine which is embodied in the two machines admitted to have been used by these defendants; that in said year he made a model of the same, exhibiting to the eye all the combinations in said machines to effect the aforesaid purposes which were represented in said machines of the said defendants; but that, from want of encouragement, and from other causes, he was unable to carry the same into practical operation until the year 1856, when the first machine operated on this principle was by him built, though, during the whole of that interval, between the time of the invention and the time when it was put into practical operation, he was urging upon every person from whom he could reasonably expect assistance the value of his plan and the confidence which he entertained in its superiority over every other machine to effect the same end.

And these defendants deny all and all manner of unlawful combination and confederacy wherewith they are by said bill charged, without this, that there is any other matter, cause, or thing, in the said complainant's said bill of complaint contained, material or necessary for these defendants to make answer unto, and not herein and hereby well and sufficiently answered, confessed, traversed, and avoided, or denied, is true, to the knowledge or belief of these defendants; all which matter and things these defendants are ready and willing to aver, maintain, and prove, as this honorable court shall direct, and humbly pray to be hence dismissed, with their reasonable costs and charges, in this behalf most wrongfully sustained.

BENJ. F. THURSTON,
Of Counsel for Def'd'ts.

In testimony whereof, The Wheeler & Wilson M'f'g Company have caused this answer to be signed by their president and their [L. S.] treasurer, and have caused their corporate seal to be affixed hereto.

NATHANIEL WHEELER, *Pres't.*
W. H. PERRY, *Treasurer.*
NATHANIEL WHEELER.

CONNECTICUT DIST., *ss:*

In Bridgeport, on this twentieth day of February, A. D. 1860, then personally appeared The Wheeler & Wilson Manufacturing Company,

by Nathaniel Wheeler, their president, and W. H. Perry, the treasurer of said company, who severally made oath that statements
26 in the preceding answer, made as within the knowledge of the corporation, are true; and the statements in said answer, made according to information and belief, are true, according to the best of the knowledge, information, and belief of the aforesaid officers of said corporation.

Before me, C. R. INGERSOLL,
U. S. Commissioner for Connecticut District.

And at the same time and place personally appeared Nathaniel Wheeler, who made oath that the facts and statements above contained in the preceding answer, as made of his own knowledge, are true; and the statements in said answer, made as according to his information and belief, are true, according the best of his knowledge, information, and belief.

Before me, C. R. INGERSOLL,
U. S. Commissioner for Conn. Dist.

Dist. Connecticut, U. S. cir. ct., cl'k's office, 20 Feb., 1860, filed.
Attest: ALFRED BLACKMAN, *Clerk.*

27 EXHIBIT A.

Original letters patent granted to Geo. H. Corliss, March 10, 1849.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, George H. Corliss, of the city and county of Providence, and State of Rhode Island, have invented certain new and useful improvements in steam-engines, and that the following is a full, clear, and exact description of the principle or character which distinguishes them from all other things before known, and of the manner of making, constructing, and using the same, reference being had to the accompanying drawings, making part of this specification, in which figure 1 is a side elevation of an engine on my improved plan; figure 2, a longitudinal vertical section; figure 3, an elevation of the valves and the arrangement of parts for working them; and figure 4, a plan thereof; figure 5 is a separate section representing a latch used in the valve gear; and figures 6 and 7, a plan and section of an air cylinder and piston for checking the motion of the valve apparatus. The same letters indicate like parts in all the figures.

In constructing the frame-work of what are known as beam-engines, it is highly important to avoid the working or yielding of the frame under the action of the varying forces of the engine, for it is to such working and yielding of the frame that the breaking of engines is mainly due. The numerous devices which have been essayed to re-

move this evil establishes, conclusively, the importance of a practical remedy. The object of the first part of my invention relates to the method of avoiding this difficulty, and consists in supporting the shaft of the working beam on two vertical standards that are erected on two horizontal beams secured and resting at the ends on the bed, the upper end of the two standards being connected to and braced with the ends of the horizontal beams by means of diagonal tension screw-braces, so that during the upward motion of the piston the strain from the base of the cylinder to the bearings of the working beam shall be along one set of diagonal tension braces, and from these bearings to the support of the crank shaft along the set of diagonal braces on the other side; and during the downward motion shall be vertically along the line of the standards on to the horizontal beams, which are prevented from working by the tension of the diagonal tension braces.

In steam-engines operated with slide valves, particularly the large condensing engines made in England, the valves are connected and moved together in pairs, one at each end of the cylinder, and, therefore, move together over the same extent of surface; and as the power is required to move them is due to the friction produced by the pressure of the steam on their surface and their range of motion under this pressure, it follows that the valves while closed require the most power, for much of this friction is relieved the moment the valves are partly opened. One of the valves must always be closed while the other is being opened or closed, hence the closed valve is moved at an entire sacrifice of power. To save this several devices have been resorted to, such as cams, the irregular working of which makes too much noise and renders the whole liable to derangement; but by my invention I am enabled to reduce the motion of the closed valve relatively to that of the other valve, and thus greatly to reduce the amount of power hereto required for this purpose. This, the second part of my invention, therefore, consists in communicating motion to the two valves from one rock-shaft by connecting each valve with a separate arm or crank-wrist of the rocker, the two arms making such an angle with each other dependent on the position of the valves and the rocker, so that the point of connection of the closed valves shall vibrate near the dead point, and therefore give but a small amount of motion to that valve, while the other, which is being opened and closed, is moving along that part of its circuit which shall give the greatest longitudinal motion, and, therefore, giving to that valve the greatest amount of motion. By this means I not only save much of the power due to the working of the valves when closed, but at the same time I attain the important advantage of greatly accelerated motion of the valves whilst opening and closing the parts.

The third part of my invention relates to the method of regulating the cut-off of the steam in the main slide valves, and consists in effecting this by means of the governor, which operates cams, so that when the velocity of the engine is too great these cams shall be moved by the contrifugal action of the regulator, that a catch on the
28 valve rods may the sooner come in contact with them to liber-

ate the valves and admit of their being closed by the force of weights or springs, and thus cut off the steam in proportion to the velocity of the engine; this being done sooner when the velocity of the engine is to be reduced, and later when it is to be increased.

In the accompanying drawing, (*a*) represents the bed of the engine, which is elevated at each end above the level of the plane of the middle part. The cylinder (*b*) is secured to one end, and the boxes (*cc*) of the crank shaft to the other. Two horizontal beams (*dd*) are placed with their ends resting on the two elevated parts of the bed and then securely bolted, and on the middle of these are erected the two standards (*ee*,) which may, however, be cast with the horizontal beams. And near the upper end these standards are formed with a hole or hollow space (*f*,) in part to reduce the weight, but chiefly to form a bearing for nuts (*gg*) that are tapped on to the ends of tension brace rods, (*hh and* h^3h^3,) one on each side of each standard, and extending down diagonally to the ends of the horizontal beams through which they pass, and to which they are firmly secured by keys (*ii*) in manner well known to engineers.

The upper end of the standards are provided with appropriate boxes for the journals of the shaft (*j*) of the working beam (*k*) in the usual manner.

The two standards are, of course, braced together in any desired manner to keep them parallel.

From the above arrangement it will be seen that, by drawing the tension brace rods by means of the nuts, the standards will be forced down on the horizontal beams, and that the tension braces will be strained or drawn tight, so that, during the upward motion of the piston, the downward force of the steam on the bed plate and the upward thrust in the boxes of the working beam shaft will be exerted along the diagonal line of the tension brace rods, (*hh*,) and from the shaft of the beam along the other diagonal tension brace rods (h^3h^3) to the boxes of the crank shaft, and that these being fully strained by the nuts, no force that is not sufficient to separate the connection will be able to force these apart to any injurious extent, so that during this upward action the frame will not work or yield. And on the return or downward stroke of the piston, the strain on the shaft of the beam will be exerted vertically on the standards, and therefore on the horizontal beams, which are held in a state of tension by the tension braces, and therefore this action of the steam will not cause the frame to work or yield materially, unless such force be sufficient to break the metal. The parts being thus braced, and under tension and pressure, independently of the force of the engine, will effectually prevent that working of the frame, which in a short time causes some part or parts of the engine to break, or become deranged.

The steam and exhaust valves (*ll*) and (*mm*) are arranged above and below the top and bottom of the cylinder in steam chests (*n*,) (*o*,) the one (*n*) at top, and formed in the cylinder head, and the other let into a recess in the bed plate. The exhaust valves (*mm*) are attached to valve rods (*pp*,) provided with appropriate heads (*qq*,) one for each, which, by connecting rods (*rr*,) are jointed to arms (*ss*) of

two levers (*t t*) that turn on fulcrum pins (*u u*,) the other arms (*v v*) being in turn connected each with a wrist (*w*) of a rock shaft (*x*.) the two wrists being distant about a quarter of a circle, so that when one is at its greatest leverage, the other is at the dead point. As one valve must not be opened until the other is closed, or nearly so, and vice versa, and the two derive their motions from one and the same rock shaft, the wrists on the rock shaft are so situated, relatively to the valves, that they are each in turn opened and closed by that portion of the motion of the wrist which communicates the greatest longitudinal motion to the connecting rod, and when one is performing this motion, the other wrist is performing that portion of its motion which communicates the least longitudinal motion to the connecting rod ; hence, whilst the two wrists are performing the same length of rotation, the one which operates the opening and closing valve gives a quick movement to its valve to open and close the port rapidly, whilst the other valve which moves over the closed port, and therefore under the full pressure of steam moves very slowly, and vice versa. The rock shaft (*x*) is provided with an arm (*y*) which receives the required vibratory motion by a connecting rod (*z*) from an eccentric (*a*) in the usual manner of operating the valve gear of steam-engines.

The steam valves (*l l*) are provided with double valve rods (*b' b'*) attached to sliding heads (*e' e'*) and connected with and operated by the rock shaft (*x*) in manner similar to the exhaust valves above described with this exception, that the levers (*d' d'*) that are con-
29 nected with the rock shaft by means of connecting rods (*e' e'*) instead of being jointed to rods connected with the slide heads of the steam valve rods, as in the exhaust valves, are each provided with a cogged section (*f' f'*) which operate sliding racks (*g' g'*,) and these racks instead of being jointed to the cross heads of the valve stems are so formed as to be engaged and disengaged with the connecting rods (*h' h'*) by means of catches (*i' i'*) on the valve rods, which catch on to corresponding lips on the racks and are there held by springs (*ii' ii'*). When the steam valves are closed, the vibration of the rock shaft (*x*) alternately moves one of the racks sufficiently far to become engaged with the catch (*i'*) of one of the rods (*h'*,) and on the return motion, so soon as the valve is sufficiently open, a projection (*j'*) on the rod (*h'*) strikes against a cam (*k'*) on a vertical rod (*l'*.) which disengages the catch from the sliding rack and permits the valve to be closed quickly to cut off the supply of steam by means of a bent lever (*m'*,) one arm of which bears against the back of a small air cylinder (*n'*) attached to the double valve rods, and the other arm having a weight (*o'*) suspended to it; the moment the catch is liberated, the gravity of the weight closes the valve to cut off the supply of steam that it may complete the stroke of the engine by expansion.

Towards the end of the closing motion of the valve the small air cylinder (*n'*) attached to the valve rods embraces a piston (*p'*) attached to the frame which condenses the air within the cylinder, and thus acts as a buffer or elastic cushion to prevent the slamming of the machinery and breakage consequent thereon.

The two steam valves are arranged, mounted, and connected in the same manner, and are therefore operated in the same manner, and are alternately operated by the rock shaft; and their connection being made with the rock shaft in the same manner, although at different points, as the exhaust valves, they of necessity operate on the same principle, with the exception specified for cutting off the steam. The cams (k' k') are helical projections on the peripheries of two cylinders on a sliding and rotating rod (l') attached to the slide (r') of the governor, (s',) so that when the governor, which receives its rotation from the crank shaft by a line shaft (t') and bevel wheels, (u' u' u' u',) moves too fast, the rising of the balls will elevate the rotating and sliding rod, (l',) and with it the helical cams, (k' k',) which, by their helical form and rotation, come in contact with the projections (j' j') on the valve rods ($h'h'$) to strike them the sooner, and therefore to liberate the valves at a shorter part of the stroke of the piston and the sooner to cut off the steam, which will reduce the power of the engine and consequently its velocity. When the balls of the governor are entirely down, as when the engine is at rest, the helical cams ($k'k'$) are below the plane of motion of the steam valve rods, so that these can have their full motion without striking the cams. In this position of the parts the steam valves will operate in manner similar to the exhaust valves, and the steam will not be cut off. All that is necessary, therefore, to work the engine full stroke is simply to liberate the slide of the governor, or disconnect the governor. When the steam valves are not to be used as cut-off valves, they are to be operated in every particular like the exhaust valves. It will be obvious, from the foregoing, that when the valves are arranged to move in planes parallel with the axis of the cylinder, as is usual with slide valves, that the rock shaft by which they are operated is to be differently located, and that whenever the location of the rock shaft is to be changed that the points of connection of the connecting rods therewith are to be placed nearer together or farther apart, so as to give the required range of motion to the valves in accordance with the principle of my invention.

The best mode of arranging the parts when the valves move in planes parallel with the axis of the cylinder is fully represented in the additional figures 8 and 9, where the same letters are used to indicate corresponding parts, as in the figures described above.

I wish it to be distinctly understood that in the mode of regulating the cut-off by the governor I do not limit myself to the use of the particular kind of cams described or represented, as the form, position, and operation of these may be greatly varied without changing the principle of this part of my invention; as, for instance, stops or cams connected with the slide of the governor by levers may be made to slide in the direction of the plane of motion of the valve rods to vary the periods of liberating the catches of the valve rods; or wedge-formed stops or cams may be substituted for the helical cams and attached to the cam rod, which in that case must not turn. The mode of applying this principle, which I have first described, is the one which I have essayed with success, and therefore I have described

it minutely; but the two modifications indicated will show clearly that the same principle is susceptible of various modifications.

30 What I claim as my invention, and desire to secure by letters patent, is, first, the method substantially as described of operating the slide valves of steam-engines by connecting the valves that govern the ports at opposite ends of the cylinder with separate arms of the rock shaft, or the mechanical equivalents thereof, so that from the motion thereof the valve that keeps its port or ports closed shall move over a less space while its port or ports is closed than the one that is opening or closing its port or ports, and vice versa, while at the same time the two arms by which they are operated have the same range of motion, as described, whereby I am enabled to save much of the power heretofore required to work the slide valves of steam-engines, and by which, also, I am enabled to give a greater range of motion to the valves at the periods of opening and closing the ports to facilitate the induction and eduction of steam, as specified. And lastly, I claim the method of regulating the motion of steam-engines by means of the centrifugal regulator, by combining the said regulator with the catches that liberate the steam valves by means of movable cams or stops, as substantially described.

GEORGE H. CORLISS.

Witnesses:
A. P. BROWNE.
E. P. MCCREA.

31 EXHIBIT B.

Reissue letters patent for improvement in cut-off and working the valves of steam-engines, granted to Geo. H. Corliss May 13th, 1851. (Original patent dated March 10, 1849.)

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, George H. Corliss, of the city and county of Providence, in the State of Rhode Island, have invented certain new and useful improvements in steam-engines, and that the following is a full, clear, and exact description of the principle or character which distinguishes them from all other things before known; and of the manner of making, constructing, and using the same, reference being had to the accompanying drawings making part of this specification, in which figure 1 is a side elevation of an engine on my improved plan; figure 2, a longitudinal vertical section; figure 3, an elevation of the valves and the arrangement of parts working them; figure 4, a plan thereof; figure 5, a separate section representing a latch used in the valve gear; figures 6 and 7, a plan and section of an air cylinder and piston for checking the motion of the valve apparatus.

The same letters indicate like parts in all the figures. In that class of steam-engines in which the steam and exhaust ports of the cylinder

are opened and closed by slide valves, whenever the valves close the ports, the steam presses them upon their seats with its whole force, and they cannot then be moved without the expenditure of a considerable amount of power; but when the valves do not completely close their ports, the steam pressing upon both sides of them does not tend to hold them upon their seats, and at these times the valves can be moved with but a small exertion of force. When a valve has closed its port, its office is performed, and hence the force exerted in any further movement of it while the port remains closed is wholly lost.

Now it is customary in this class of engines to connect the valves rigidly, so that when one is moved the other is forced to move with it to the same extent; the closed valve is therefore moved with the opening one, and consequently the whole amount of force consumed in moving it while closed is expended to no good purpose, and tends only to increase the wear and tear of the engine. To avoid this sacrifice of power, and at the same time to retain the advantages which result from the connection of the valves, is the object of the first part of my invention, which consists in moving each of the steam and exhaust valves of an engine independently by means of one crank wrist of a series, which are all attached to a common disc, wrist plate, or other equivalent device, which is secured to and moved with a rock shaft.

The several wrists which work the different valves are arranged upon the wrist plate in such positions with respect to the rods and levers, or other devices which connect them with the valves, that they shall act like so many cranks, each of which vibrates near its dead point, or point of slowest throw, and therefore imparts but little movement to the valve it actuates when the latter is closed, while each moves with its fastest throw, and therefore communicates the greatest movement to its valve when the latter is open. Two great advantages result from this method of working the valves; in the first place, much of the power heretofore expended in moving the closed valve is saved; and secondly, the wire-drawing of the steam is reduced, because the valves, while opening and closing the ports, are moved with increased speed.

The second part of my invention relates to the method of regulating the cut-off of the steam in its passage into the engine, and consists in effecting this by means of the governor which operates cams; so that when the velocity of the engine is too great these cams shall be moved by the action of the regulator to such positions that catches on the valve rods may the sooner come in contact with them to liberate the valves, and admit of their being closed by the force of weight or springs, and thus cut off the steam in proportion
32 to the velocity of the engine; this being done sooner when the velocity of the engine is to be reduced, and later when it is to be increased.

In the steam-engine represented in the accompany drawings the steam and exhaust valves *l*, *l*, and *m*, *m*, are situated in steam chests *n*, *o*, at each extremity of the steam cylinder; the chest *n*, at the top,

is formed in the cylinder head, while the other, *o*, is let into a recess in the bed plate. Each exhaust valve *m* is attached to one extremity of a valve rod *p*, which is fitted at its opposite extremity with a sliding head *q*, that is linked by a connecting rod *r* to one arm *s* of a bell crank *t*. The other arm, *v*, of the bell crank is connected by a rod with a wrist pin *w* on the wrist plate *x*. The latter is secured to a rock shaft to which the requisite vibratory motion is imparted by an eccentric *a*, through the intervention of an eccentric rod and an arm *y*, secured to the rock shaft.

The wrists, *w*, of the two valves are in this example a quarter of a circle distant from each other, and the two connecting rods extend in opposite directions from the rock shaft; hence, when one wrist is at its point of its greatest throw, the other is at its dead point; and when one is imparting to its rod and the valve connected therewith the greatest movement, the other is imparting to the valves the least. Each valve is therefore moved alternately fast and slow; and the fast movement of one is effected during the slow movement of the other; nearly the whole movement or throw of each valve being effected while the port is either partially or wholly open, at which time the least power is required to move it; while, as the small remnant of the throw when the port is closed is effected during the slow movement, but little power is then required, as the distance to which the valve is moved is now very short. The steam valves *l*, *l*, are worked in a manner similar to that of the exhaust valves, with the exception of an arrangement by means of which they are made to close and cut off the supply of steam at any required portion of the stroke. The valve rods *b* of these valves are double, and instead of being permanently linked to their appropriate bell cranks, are each connected by a detachable link *h'*, with a rack *g'*, whose teeth engage with those of a tooth sector *f'* on the bell crank. This detachable link *h'* is hinged at one extremity to the cross-head *c'*, which unites the two members of the double valve rod; it has a shoulder *i'* at its opposite extremity, which engages in a corresponding socket on the rack, and is kept in place by a spring *i''*. This link *h'* is also fitted near the rack with a projection *j'*, which is struck at the proper moment to detach the link from the rack by a revolving helical cam *k'*. The helical cams which detach the links *h' h'* of the two steam valves *l*, *l*, are both secured to an upright shaft *l'*, which is caused to revolve by the movement of the crank shaft, and is arranged at the same time to move freely up or down in its boxes. This shaft is connected at *r'* with the governor, (which, in the present instance, is of the centrifugal variety, that being the kind I have used, deeming it best,) so that it shall move up or down as the balls of the governor rise and fall. When the governor balls *s' s'* are at their lowest position, the shaft *l'* is depressed so far that the helical cams *k' k'* are below the range of the valve link *h' h'*, and consequently cannot detach them; hence, in this position of the governor balls, the steam valves being connected with their wrist pins throughout the whole length of the stroke, are opened and closed in the same manner as the exhaust valves. As, however, the velocity of the engine is increased, and

the governor balls rise under the increased centrifugal force, the upright shaft l' is correspondingly raised, and the cams being now revolved within range of the valve links, strike the projections j', and detach the links k' from their racks.

The helical cams extend round the shaft in the same direction as the latter is turned, consequently the higher the shaft l' and its cams are raised, the sooner will the cams strike the projections and detach the links. As soon as the links are detached, the valves being entirely disconnected from the mechanism by means of which they are opened, are consequently free to close. As the steam valves in the steam-engine represented move horizontally, they do not tend to close by their own weight, and are consequently closed by means of weights, o', o', which act through the intervention of bent levers, or bell cranks m', upon the cross blocks n', secured to their respective valve rods. In order to prevent the jar which would result from the sudden stoppage of the motion of the weight, each cross block n' has a cylindrical socket formed in the face nearer the steam cylinder, and a piston p' is secured to the engine frame which enters the cylindrical socket and compresses the air within it to form an elastic cushion to prevent the jar. As the racks g' are moved back by the action of the wrist pins and the bell cranks, the shoulder of the link re-engages with the socket on the rack, so that the valve being
33 now reconnected with the valve mechanism, is opened by the wrist pin at the proper moment to admit steam into the cylinder. When the steam valves are not used as variable cut-off valves, they are to be operated in every particular like the exhaust valves. It is obvious, from the foregoing description, that when the valves are so arranged that they move parallel with the axis of the cylinder, as is the customary arrangement in slide valve engines, the rock shaft by which they are operated may, with advantage, be located in a position different from that described above, and the valve connections must be adapted to this change.

A convenient mode of arranging the several parts, when the valves move parallel with the axis of the cylinder, is represented at figures 8 and 9, in which the letters indicate the parts corresponding with those indicated by them in the arrangement before described.

I wish it to be distinctly understood that, in the mode of regulating the cut-off by the governor, I do not limit myself to the use of the particular kind of cams described or represented, as the form, position, and operation of these may be greatly varied without changing the principle of this part of my invention; as, for instance, stops or cams connected with the slide of the governor by levers may be made to slide in the direction of the plane of motion of the valve rods to vary the periods of liberating the catches of the valve rods, or wedged-formed stops or cams may be substituted for the helical cams and attached to the cam rod which in that case must not turn.

The mode of applying the principle which I have first described is the one which I have essayed with success, and therefore I have described it minutely; but the two modifications indicated will show clearly that the same principle is susceptible of various modifications.

What I claim as my invention, and desire to secure by letters patent is, first, the method substantially, as described, of operating the slide valves of steam-engines by connecting the valves that govern the ports at opposite ends of the cylinder with separate arms of the rock shaft or the mechanical equivalents thereof; so that, from the motion thereof, the valve that keeps its port or ports closed shall move over a less space while its port or ports is closed, than the one that is opening and closing its port or ports, and *vice versa;* while, at the same time, the two arms by which they are operated have the same range of motion as described, whereby I am enabled to save much of the power heretofore required to work the slide valves of steam-engines, and by which, also, I am enabled to give a greater range of motion to the valves, at the periods of opening and closing the ports, to facilitate the induction and eduction of the steam, as specified.

And, lastly, I claim the method of regulating the motion of steam-engines by means of the regulator, by combining the said regulator with the catches that regulate the steam valves by means of movable cams or stops substantially as described.

GEORGE H. CORLISS.

Signed in the presence of—
JOHN H. CLARKE.
E. J. NIGHTINGALE.

34 EXHIBIT J.

Extract from the circular of F. E. Sickles and Truman Cook, dated February 17, 1844.

In reference to the before-mentioned cut-off, the undersigned would respectfully state that they are the joint and equal owners of the same, and that the merits of the cut-off is more fully known when constructed and applied under the supervision or direction of the inventor, (Mr. F. E. Sickles;) and they are fully aware that great discredit has been done to said invention, by its having been constructed and applied by pseudo inventors and others, whose only interest in said cut-off has been the profits arising from the construction of the same, such persons well knowing that a cut-off exhibiting merits somewhat superior to any other in use would give satisfaction to owners of steamboats.

The above cut-off has been constructed, according to the directions of Mr. Sickles, for the following steamers, viz: The Charter Oak, New Haven, New York, Rhode Island, Massachusetts, Highlander, Mohegan, Burlington, and U. S. steamer Missouri; and the same has been applied, according to Mr. Sickels's directions, to the engines of the above boats, excepting those of the steamer Missouri. The merits of the said cut-off have not been fully developed, even on board of the above steamers, (except the steam packet Burlington, on Lake Champlain,) in consequence of various establishments in the city of New York for building steam-engines having infringed upon said patent, thereby causing a competition in the construction

of the said cut off, and so reducing the price paid for construction that Mr. Sickles, for the price paid, has been unable to construct such an apparatus as his feelings and interests would have otherwise dictated.

In regard to the working of said cut-off when a vessel (to the engine of which it may be attached) is encountering a boisterous sea, the cut-off operates as a perfect governor to the engine, owing to the peculiarity of the principle upon which it operates, the engineer being enabled to carry steam without shutting off the engine, or fear of any dangerous results, as the cut-off in its operations will work with a rapidity corresponding with that of the engine; whereas when using the old cam-board cut-off when the engine has a sudden impetus, in consequence of the insufficient immersion of the wheels, caused by the agitation of the sea, the consequent and sudden action upon the cam-board, give a sudden and lengthened application of steam upon the piston, and the anticipated results from such circumstance would not only be impracticable but dangerous; consequently, when using the cam-board cut-off, the engineer is under the necessity of acting as governor to the engine, by letting on and shutting off steam, as he, in his judgment, may deem practicable. And that the said cut-off, when properly constructed and applied, is no more liable to disarrangement than the connecting rod of the engine, likewise being susceptible of adjustment so as to cut off at any desired part of the stroke of the piston less or more than one half or wholly suspended in its operations without being under the necessity of stopping or even checking the engine in its motion. The cut-off will seldom exceed in weight three hundred pounds.

The said cut-off can be applied to high as well as low-pressure engines, to puppet valves, whether single or double, and likewise to slide valves.

Information necessary to enable Mr. Sickels to construct the said patent cut-off so as to be susceptible of being applied to any particular engine may be communicated by a drawing showing the dimensions of the side pipes, steam-chest valves, lifter, and bonnet of the steam chest of the engine to which it may be desired to be attached.

Particulars in relation to the constructing and right to use the said cut-off may be obtained by calling on Mr. Sickels, at the city foundry, in the city of New York, where he is at present located, or by addressing Mr. Truman Cook, New York.

We deem it proper hereby to caution and forbid all persons whatsoever from constructing, using, meddling, or interfering with the said patent cut off, except such persons as have a sealed instrument signed by Frederick E. Sickels and Truman Cook, granting authority so to do, under the extreme penalty of the law, and of being prosecuted therefor.

FREDERICK E. SICKELS.
TRUMAN COOK.

NEW YORK, *February* 17, 1844.

35 EXHIBIT L.

Original letters patent granted to Geo. H. Corliss, July 29th, 1851.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all whom it may concern:

Be it known that I, George H. Corliss, of the city and county of Providence, and State of Rhode Island, have invented a new and useful improvement in the method of actuating variable cut-off valves for steam and gas engines; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, which form part of this specification, and in which,

Figure 1 represents a side elevation of a beam engine with my valve gear applied thereto; figures 2 and 3 are fragmentary side elevations of the steam cylinder and valve gear; and figure 4 is a section of one of the valve chests and the parts adjacent thereto.

My improvement has reference to that class of cut-off valve motions in which the connection between the valve and the eccentric, or the equivalent thereof, which opens the valve, is broken to allow the valve to move independently of the eccentric and close its steam port before the piston has completed its stroke: and my improvement consists in effecting this disconnection of the valve and the eccentric gear, or the equivalent thereof, by imparting to the lifting rod a lateral movement, which is limited and controlled by an adjustable stop and spring; so that the lifting rod not only performs the duty usually imposed upon it of opening the valve, but also performs the office of a catch or latch, in connecting and disconnecting the valve with the eccentric gear.

In the accompanying drawings, A is the steam cylinder and B the crank shaft of the engine. The steam cylinder is fitted with two side pipes, C, D, which form the valve chests in which the valves are contained. The side pipe C, further from the crank shaft B, contains the steam valves, and is connected with the steam pipe which conveys the steam from the boiler; the other side pipe contains the exhaust valves, and is connected with the exhaust pipe, through which the exhaust steam from the cylinder is discharged. The steam and exhaust valves are, in this instance, of the slide variety, and each is moved to open and close its respective port by an arm *y*, which projects from a short rock shaft *z*. These rock shafts extend transversely through stuffing boxes in the sides of their respective valve chests, and their projecting extremities are fitted with arms *a a*, *b b*. The arms *a a* of the exhaust valves are connected by means of lifting rods *b b* with separate crank wrists *c c*, secured to a disc plate E, to which a rocking motion is imparted by the eccentric F through the intervention of the eccentric rod *d* and a crank *f* secured to the disc plate E. The connection of these exhaust valves with the crank

wrists of the disc plate, and thence with the eccentric, are permanent; and hence the exhaust valves will be alternately opened and closed with a regular movement, the opening of one exhaust valve being simultaneous with the closing of the other.

The arms *g g* of the steam valve rock shafts terminate in toes *o o*, and are operated by lifting rods *h h*, which are pivoted to suitable crank wrists *e e* upon the disc plate E. These lifting rods terminate in hooks *i i*, which engage with the toes *o o* of the rock shaft arms, and are kept engaged with them by springs *j j*, which bear upon the backs of the lifting rods; hence as long as these hooks continue engaged with the toes of the rock shaft arms, the steam valves will be opened and closed with a regular movement in the same manner as the exhaust valves; while, if the hooks of the lifting rods be disengaged from the toes at any portion of the stroke, the connection of the steam valves with the eccentric will be broken, and the steam valves will be free to close, and thus cut off the passage of the steam to the steam cylinder.

36 In order to effect this disengagement of the lifting rods, which communicate the movement of the eccentric to the steam valves, each rod is fitted with an adjustable stop *k*, *k*, against which the face of the rod bears in moving, and which can be moved to cause the hooked extremity of the rod to detach itself from the respective toe of the rock shaft arm when the steam piston has accomplished any required portion of its stroke. These stops are constructed to slide in blocks *m*, *m*, secured to the frame work or other convenient portion of the engine; their extremities bear against two inclined blocks *l*, *l*, which are secured to a rod G, by raising or lowering which, the stops are moved to effect the disengagement of the lifting rods when the piston has accomplished a less or greater portion of its stroke. This sliding rod G, in the examples represented in the drawing, is constructed to be moved by hand through the intervention of a rack *n*, and worm *p*, the last of which is turned by hand to screw up or screw down the sliding rod; but the sliding rod G, may be moved by the engine itself, by connecting it with the slide of the governor, so that as the latter is moved, the point at which the cut-off is effected will be varied.

The inclined blocks *l*, *l*, are of such form that when they are raised to their highest position, as at fig. 3, the stops *k*, *k*, will be so far projected that the lifting rods *h*, *h*, bearing upon them, will, in moving, disengage from the toes of the rock shaft arms before the valves have been moved sufficiently to open their respective ports; while, if the inclined blocks are depressed by the rod G, to their lowest position, as at fig. 1, the stops *k*, *k*, will recede in their slide blocks *m*, *m*, sufficiently to have no action upon their respective lifting rods, and hence the latter will continue engaged with their respective toes throughout the whole extent of the stroke. If the inclined blocks be set between these two extreme positions, as at fig. 2, the stops will be more or less projected, to detach the lifting rods sooner or later, as may be required to regulate the amount of steam admitted to the steam cylinder.

In order to effect the closing of the steam valves after they are disconnected from the eccentric gear, the rock shaft arm appertaining to each of them has a weight *r*, suspended from it by a rod S. These weights are sufficiently heavy to effect the instantaneous closing of the valve whenever its appropriate lifting rod is disengaged from the toe of the rock shaft arm. In order to prevent the slam and jar that would result from the sudden closing of the valves, these weights are fitted to move easily in appropriate sockets, formed, in the present example, in the bed plate of the engine. The weights moving in the sockets act as pistons to compress the air therein, and thus retard their descent, and as air-cushions to prevent the slam or jar. If the compression of the air was continued throughout the whole descent of the weight, its motion would be too much retarded to enable it to close the valve with the requisite speed; an orifice, *t*, figure 1, is therefore made in each socket, near its lower extremity, to permit the free entrance and exit of air. This orifice is in such a position, that the weight, in descending, passes it, and thus cuts off the escape of the air remaining in the socket just before the valve closes its port, when the air caught or shut up in the socket, being compressed, will retard the further movement of the weight, and will act as an air-cushion to prevent the slam or jar.

When the stops are acting, the lifting rods are alternately disengaged in their inward movement towards the centre of the disc plate, to allow the valves to close under the action of their respective weights; as each lifting rod is moved outward, its extremity, being pressed by its appropriate spring *j*, against the toe of its respective rock shaft arm, is caused to re-engage therewith in time to open the valve at the returning rock of the disc plate. In order to insure the closing of each steam valve before it is reopened, a curved snug V, is projected from the face of each lifting rod, *h*, which, in the outward movement of the latter, would strike against the lower side of the toe of the rock shaft arm, and thus close the latter, if by any accident it was not previously closed by its appropriate weight.

In order to lessen the wear of the toes and the hooks of the valve gear, their rubbing faces are faced with hardened plates of steel, which, when worn, can be readily replaced.

The arrangement of the lifting rods, and the method of operating them by the disc plates, as represented in the accompanying drawings, is peculiarly suited to this method of effecting the disengagement of the valves from the mechanism by which they are opened, for the disc plate imparts a transverse motion to the connecting rods, which causes them to rock upon the stops, and thus slide off their respective toes on the rock shaft arms. But while I prefer this arrangement of eccentric gear, I wish it to be understood that I do not restrict myself to its employment, as my improvement may
37 be applied to many other systems of mechanism by which valves are opened. As such systems may not possess the peculiar rocking motion I have mentioned, it will be necessary, in some cases, to disengage the lifting rods by a positive movement, which may, at the proper moment, be imparted to the lifting rods by some

moving member of the engine, through the intervention of any convenient and suitable mechanical device.

In combination with the reciprocating motions communicated to the lifting rods by the eccentric gear, I claim imparting a lateral movement to the free extremities of said lifting rods to disconnect them from the valves and permit the latter to close to cut off the steam or other expansive fluid by which the engine may be driven, whereby these rods are made to perform their usual duty of opening the valves, and, in addition, that of catches or latches in alternately connecting the valves with, and disconnecting them from, the mechanism by which they are opened, thus greatly simplifying the construction of the valve gear, rendering the same more durable and less liable to get out of order.

In testimony whereof, I have hereunto subscribed my name.

GEORGE H. CORLISS.

Witnesses:

THOMAS A. JENCKES.

W. H. HENDERSON.

38 *Letters patent granted to Noble T. Greene, dated March 13th, 1855.*

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Noble T. Greene, of Bridgeport, in the State of Connecticut, have invented certain new and useful improvements in the apparatus for operating the cut-off valves of steam-engines and regulating the same, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings making part of this specification, in which figure 1 is a front elevation, and figure 2 an end elevation, of my improved apparatus. The same letters indicate like parts in both the figures.

In my said invention the valves are connected with, and depressed by, rocking levers, or their equivalents, by any suitable mode of connection, and these levers are operated in one direction by the closing of the valves, either by their gravity, by weights connected therewith, or any other suitable means to ensure the rapid closing of the ports, and in the opposite directions to open the ports by means of two spring tappets, mounted on or in a sliding bar, having a positive longitudinal motion derived from an eccentric or other suitable part of the engine; and the said tappets are free to slide on or in the said bar, and at right angles to its length, for the purpose of passing by the levers in the return motion, and of being adjusted to any portion of the stroke, and to admit of adjustment to liberate the valves at any portion of the stroke of the piston.

And this part of my invention consists in combining with the levers that liberate the valves the spring tappets on the sliding bar when the said tappets are movable on the said sliding bar at right angles to the line of its motion, or nearly so, to permit the return of the

tappets after the valves have been closed rapidly by gravity, or the equivalent thereof, and preparatory to the reopening of the valves. And *my* invention also consists in regulating the periods of closing the valves by means of a gauge bar, which is adjustable by a governor or other means when combined with the spring tappets to regulate their position and thereby determine the periods of liberating the valves that they may be closed by gravity, or other equivalent means, whilst the period of opening the valves remain unchanged."

In the accompanying drawings *a. a.* represent two slide valves, (for which other valves may be substituted,) connected by rods *b. b.* with the upper arms of two rocking levers *c. c.* mounted on arbors *d. d.*, having arms *e. e.*, to which are suspended by weights *f. f.* to close the valves when the levers *c. c.* are liberated. When the valves are closed the rock levers are vertical for a horizontal engine, although this position may be varied.

Below the two rock levers is placed a bar *g.* mounted in suitable standards *h. h.*, and receiving a positive longitudinal motion from an eccentric *i.* or other suitable part of the engine. And in this bar are two mortises passing through it at right angles to its length, and in which are fitted, so as to work therein freely, but accurately, two tappets *j. j.*, formed with shoulders *k. k.*, to determine the limit of their motion downward, and forced upward by a spring *l.* attached to the lower face of the bar and acting by its tension to force the tappets upwards and against the lower edge of a gauge bar *m.* placed parallel with the line of motion of the tappet bar. This gauge bar has a perpendicular stem *n.* fitted to slide in a standard *o.*, where it can be held by a set-screw, or other known means, at any point of adjustment required. Or, instead of this, the stem may be connected with the governor to determine, by the velocity of the engine, the position of the gauge bar, and hence the hight to which the tappets may be forced up by the spring, which will determine the period of closing the valves.

It will be seen from the foregoing that as the tappet bar moves in the direction of the arrow, one of the tappets is brought in contact with the inner face of the lower arm of one of the levers, and causes it to turn on its axis, and thereby to open the corresponding valve. And whilst this takes place, the other tappet passes under the other rocking lever without moving it, the tappet and lever being rounded so that when they come in contact the tappet will be forced down until it shall have passed by the lever, when the spring forces
39 it up, so that on the return motion of the bar this tappet operates the corresponding lever to open its valve, whilst the other tappet passes under its corresponding lever. Now, it will be seen that by the motion of the tappet bar, the two tappets always act upon and open the valves at the same periods, but that the periods when the tappets shall liberate the rock levers to permit the valves to be closed depends upon the elevation of the tappets: that is, the lower the tappets are, the quicker they will liberate the levers, and vice versa; and therefore, by simply elevating or depressing the gauge

bar the period of closing the valves can be changed, whilst the period of opening them remains the same.

I do not wish to be understood as limiting myself to the special construction and arrangement of the several parts, but to cover all merely formal variations.

What I claim as my invention and desire to secure by letters patent is, combining with the rocking levers, or their equivalents for operating the valves, the spring tappets on the sliding bar substantially as described, and for the purpose specified.

And I also claim, in combination with the sliding spring tappets that operate the rock levers, substantially as described, the employment of the gauge bar, or any equivalent therefor, to regulate the period of closing the valves, whether the said gauge bar be regulated by a governor or by other means as set forth.

NOBLE T. GREENE.

Witnesses:
WM. H. BISHOP.
ANDREW DELACY.

40 EXHIBIT M.

Reissue letters patent No. 907, *granted to F. E. Sickels, Feb.* 21, 1860.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Frederick Ellsworth Sickels, of the city, county, and State of New York, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the character thereof, which distinguishes it from all other things before known, and of the manner of making and using the same, reference being had to the accompanying drawings, which make a part of this specification.

The nature of my invention consists in an adjustable (that is, adjustable while the engine is in motion) expansion of steam, with the aid of a motion that I call an independent motion, (because it is not controlled by a lifter motion that approaches to a state of rest as the piston of the engine approaches the middle of the cylinder, and is therefore able to act when such motion alone would be inefficient,) to determine when a weight or spring (or any equivalent force which has previously been brought into position to act) shall commence to close a separate moving cut-off valve for each end of the cylinder, (thus allowing each valve to move quick in closing without acting on the other, and also avoiding expanding the steam in the connecting pipe,) the whole operating to effect an efficient adjustable expansion of steam in steam-engines.

In the accompanying drawing, sheets 1, 2, and 3, three views are shown of this improvement in connection with others patented to me

on the same day as this, and they will be described in part to facilitate the explanation of the improvement herein patented, notwithstanding it may be used without them. The same letters refer to the same parts in each figure. F is a valve rod or stem, having a piston or plunger attached to its upper end, operating within a reservoir A, shaped smaller at the bottom, which may confine the fluid contained therein, substantially in the same manner as described in the patent granted to me the 20th of May, 1842, so as to regulate the velocity of a falling weight connected to the stem, that is sufficient to overcome all friction in closing the valve; which weight, if not furnished by or with the valve selected, should be added thereto. To this rod or stem the valve must be attached. Either single, double, or slide valves may be used. A spring L′ has a catch piece L″ connected to it that fits into a notch in the stem and extends beyond, which piece L″ has a curved projection S′ at the extreme end against which the outer face of the arm or wiper L strikes as it vibrates on its vertical axis. The outer face of this arm or wiper is parallel with its shaft or axle, and is of greater length than the motion of the lifter, so that it can act upon the curved projection on the catch piece L″ as it is carried up and down by the lifter so as to determine the time when the weight or other independent force shall close the valve. The vibratory motion of the arm or wiper L, is obtained, as shown in the drawings, in the following manner:

On its axle there is an arm W, connected by a rod Y with a similar arm W′ on the upper end of a vertical shaft Q, which has a spring arm T at its lower end, (the outer end handle form,) with its under face provided with a fillet or catch to fall into the teeth on the upper face of the sector P, that vibrates on the axis of the shaft Q, that is held by means of arms U, U, that project from two collars that turn, one on the lower end of this shaft Q, and the other on the upper end of a corresponding shaft O, below it. From one end of this sector a connecting rod R extends to one arm of a bell crank L, the other arm of which is connected by a connecting rod N with the strap M of the eccentric I, and at right angles to the eccentric rod J that operates the rock shaft C of the lifters A′, A″, so that the sector P, with the parts deriving motion from it, are moving while the lifters are in a state of rest, and therefore the liberations of the valve will be more rapid and can be regulated with more accuracy at this period of the stroke of the piston than if this lifter motion alone was used. The shaft O, which is below, has a spring arm S, similar and corresponding to the one T, before described, and at its lower end an arm B′ and connecting rod C′, corresponding with the arm W and rod Y above; and all other corresponding parts that work the cut-off valve for this end of the cylinder are substantially the same as the
41 parts above described for the other end of the cylinder. The sector P has a plate P″ above and parallel with it, for the purpose of strength, and to act as a guard for the spring arms S, T.

The face of the sector P is provided with two sets of teeth, each extending from the middle or arms U, U, to the ends, and the length of each part of the sector is such that the motion of the spring arms

S, T, from one extremity to the other of the sector, shall shift the position of the arm or wiper L and the corresponding one below so that when the spring arms are at the outer end of the segment the arms or wipers shall vibrate without permitting the weights to move the valves to cut-off; and by moving them towards the middle, the extent of the cut-off shall be reduced from the maximum to the minimum: that is to say, to cut off from the greatest to the least portion of the stroke.

It will be evident from the foregoing that any motion derived from any part of the engine may be substituted for the motion of the arms or wipers, provided it has motion as distinguished from the lifter motion, as, for instance, instead of the horizontal vibratory motion of the arms or wipers, the time when the weight may be permitted to act to close the cut-off valve may be regulated by a vertical descending motion as the lifter rises; and in this case it will be by the cooperation of this motion with another motion that a more restricted regulation is effected, and this independent motion may be derived from any moving parts of the engine other than the lifter; that is, the piston rod, the beam, crank, shaft, etc., and other mechanism than the connecting and disconnecting catch may be used in the transferring the weight from the mechanism that lifts it to the mechanism that regulates its fall; and other mechanism than this for regulating its fall and raising it may be used, and other valve motions may be used in carrying out this invention; and other means of adjusting the action of the independent motion may be substituted for that here shown.

What I claim as new and desire to secure by letters patent is, adjusting the expansion of steam in steam-engines, with the aid of an independent motion, to determine when a weight or spring shall commence to close a separate moving cut-off valve for each end of the cylinder.

FREDERICK E. SICKELS.

Witnesses:
C. W. GEDES,
F. S. MEYER.

42 EXHIBIT N.

Reissue letters patent No. 908 granted to F. E. Sickels, Feb. 21, 1860.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Frederick Elsworth Sickels, of the city, county, and State of New York, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the character thereof, which distinguishes it from all other things before known, and of the manner of making and using

the same, reference being had to the accompanying drawings, which make a part of this specification:

The nature of my invention consists in the combination of a cam, arm, or wiper, moved by an independent motion, (that is, a motion not controlled by a lifter motion that approaches a state of rest as the piston approaches the middle of the cylinder, and is therefore able to disconnect the catch with greater accuracy and certainty than if a lifter motion alone was used,) with a reciprocating trip and catch to liberate a spring weight or other force to close a cut-off valve, it being readily adapted to various forms of valve gearing and valves. In operating the trip and catch with the lifter motion alone, as it approaches a state of rest, the small amount of motion at this time will not determine the disengagement with accuracy, as an increase of friction while in operation will delay or prevent the disengagement by increasing the spring in the parts conveying or resisting the tripping force; but if an independent motion is used, either in connexion with a lifter motion or otherwise, an increase in friction could not so materially impair the accuracy of the disengagement.

In the accompanying drawing, sheet Nos. 1, 2, and 3, three views are shown of the improvement in connection with others patented to me the same day as this, and they will be described in part to facilitate the explanation of the improvement herein patented, notwithstanding it may be used without them. The same letters refer to the same parts in each figure. F is a valve rod or stem, having a piston or plunger attached to its upper end, operating within a reservoir A, shaped smaller at the bottom, which may confine the fluid contained therein as the plunger descends, substantially in the same manner as described in the patent granted to me the 29th of May, 1842, so as to regulate the velocity of a falling weight connected to the stem that is sufficient to overcome all friction in closing the valve. To this valve or stem the rod must be attached. Any form of valve may be used—either single, double, or slide valve.

A spring L′ has a catch piece L″ connected to it that fits into a catch formed by the catch G, and extends beyond, which piece L″ has a curved projection S′ at the extreme end, against which the outer face of this arm or wiper L strikes as it vibrates on its vertical axis. The outer face of this arm or wiper is parallel with its shaft or axle, and is of greater length than the motion of the lifter, so that it can act upon the curved projection on the catch piece L″, as it is carried up and down by the lifter, so as to determine the time when the weight shall close the valve. The vibratory motion of the arm or wiper L is obtained in the following manner: On its axle there is an arm W′ connected by a rod Y, with a similar arm W′ on the upper end of a vertical shaft Q, which has a spring arm T at its lower end, (the outer end handle form,) with its under face provided with a fillet or catch to fall into the teeth on the upper face of sector P, that vibrates on the axis of the shaft Q, and is held by means of arms U, U, that project from two collars that turn, one on the lower end of the shaft Q, and the other on the upper end of a corresponding shaft O below it.

S, T, from one extremity to the other of the sector, shall shift the position of the arm or wiper L and the corresponding one below so that when the spring arms are at the outer end of the segment the arms or wipers shall vibrate without permitting the weights to move the valves to cut-off; and by moving them towards the middle, the extent of the cut-off shall be reduced from the maximum to the minimum: that is to say, to cut off from the greatest to the least portion of the stroke.

It will be evident from the foregoing that any motion derived from any part of the engine may be substituted for the motion of the arms or wipers, provided it has motion as distinguished from the lifter motion, as, for instance, instead of the horizontal vibratory motion of the arms or wipers, the time when the weight may be permitted to act to close the cut-off valve may be regulated by a vertical descending motion as the lifter rises; and in this case it will be by the cooperation of this motion with another motion that a more restricted regulation is effected, and this independent motion may be derived from any moving parts of the engine other than the lifter; that is, the piston rod, the beam, crank, shaft, etc., and other mechanism than the connecting and disconnecting catch may be used in the transferring the weight from the mechanism that lifts it to the mechanism that regulates its fall; and other mechanism than this for regulating its fall and raising it may be used, and other valve motions may be used in carrying out this invention; and other means of adjusting the action of the independent motion may be substituted for that here shown.

What I claim as new and desire to secure by letters patent is, adjusting the expansion of steam in steam-engines, with the aid of an independent motion, to determine when a weight or spring shall commence to close a separate moving cut-off valve for each end of the cylinder.

FREDERICK E. SICKELS.

Witnesses:
C. W. GEDES,
F. S. MEYER.

42 EXHIBIT N.

Reissue letters patent No. 908 granted to F. E. Sickels, Feb. 21, 1860.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Frederick Elsworth Sickels, of the city, county, and State of New York, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the character thereof, which distinguishes it from all other things before known, and of the manner of making and using

the same, reference being had to the accompanying drawings, which make a part of this specification:

The nature of my invention consists in the combination of a cam, arm, or wiper, moved by an independent motion, (that is, a motion not controlled by a lifter motion that approaches a state of rest as the piston approaches the middle of the cylinder, and is therefore able to disconnect the catch with greater accuracy and certainty than if a lifter motion alone was used,) with a reciprocating trip and catch to liberate a spring weight or other force to close a cut-off valve, it being readily adapted to various forms of valve gearing and valves. In operating the trip and catch with the lifter motion alone, as it approaches a state of rest, the small amount of motion at this time will not determine the disengagement with accuracy, as an increase of friction while in operation will delay or prevent the disengagement by increasing the spring in the parts conveying or resisting the tripping force; but if an independent motion is used, either in connexion with a lifter motion or otherwise, an increase in friction could not so materially impair the accuracy of the disengagement.

In the accompanying drawing, sheet Nos. 1, 2, and 3, three views are shown of the improvement in connection with others patented to me the same day as this, and they will be described in part to facilitate the explanation of the improvement herein patented, notwithstanding it may be used without them. The same letters refer to the same parts in each figure. F is a valve rod or stem, having a piston or plunger attached to its upper end, operating within a reservoir A, shaped smaller at the bottom, which may confine the fluid contained therein as the plunger descends, substantially in the same manner as described in the patent granted to me the 20th of May, 1842, so as to regulate the velocity of a falling weight connected to the stem that is sufficient to overcome all friction in closing the valve. To this valve or stem the rod must be attached. Any form of valve may be used—either single, double, or slide valve.

A spring L′ has a catch piece L″ connected to it that fits into a catch formed by the catch G, and extends beyond, which piece L″ has a curved projection S′ at the extreme end, against which the outer face of this arm or wiper L strikes as it vibrates on its vertical axis. The outer face of this arm or wiper is parallel with its shaft or axle, and is of greater length than the motion of the lifter, so that it can act upon the curved projection on the catch piece L″, as it is carried up and down by the lifter, so as to determine the time when the weight shall close the valve. The vibratory motion of the arm or wiper L is obtained in the following manner: On its axle there is an arm W′ connected by a rod Y, with a similar arm W′ on the upper end of a vertical shaft Q, which has a spring arm T at its lower end, (the outer end handle form,) with its under face provided with a fillet or catch to fall into the teeth on the upper face of sector P, that vibrates on the axis of the shaft Q, and is held by means of arms U, U, that project from two collars that turn, one on the lower end of the shaft Q, and the other on the upper end of a corresponding shaft O below it.

From one end of this sector a connecting rod R extends to one arm of a bell crank L, the other arm of which is connected by a connecting rod N with the strap M of the eccentric I, and at right angles to the eccentric rod J that operates the rock-shaft C of the lifters, A′ A″, so that the sector P, and the parts deriving motion from it, are moving while the lifters are approaching a state of rest; and therefore the disconnection of the catch piece from the catch to liberate the weight or spring that closes the valve will be more rapid, and can be regulated with more accuracy at this period of the stroke of the piston than if the lifter motion alone was used. The shaft O, which is below, has a spring arm S similar and corresponding
43 to the one T before described, and at its lower end an arm B′ and connecting rod C corresponding with the arm W and the rod Y above; and all other corresponding parts, to work the cut-off valves for the other end of the cylinder, are substantially the same as the parts above described.

The sector P has a plate P′ above and parallel with it, for the purpose of strength, and to act as a guard for the spring arms S, T; the face of the sector P is provided with two sets of teeth, each extending from the middle or arms U, U to the ends, and the length of each part of the sector is such that the motion of the spring arms S, T, from one extremity of the sector to the other, shall shift the position of the arm or wiper L and the corresponding one below, so that when the spring arms are at the outer end of the segment the arms or wipers shall vibrate without permitting the weight to move the valve to cut-off, and by moving them towards the middle the extent of the cut-off shall be reduced from the maximum to the minimum; that is to say, to cut off from the greatest to the least portion of the stroke; and it will be evident that the reciprocating trip and catch can be placed to disconnect one part of the reciprocating valve motion from the other part, at any convenient point on the mechanism between the source of this motion, as derived from the engine, and the valve; it being desirable, however, to place it as near the valve as practicable, so that there will be as little friction as possible in the liberated parts to encounter in rapidly closing the valve.

C is a rock shaft having a reciprocating movement imparted to it by the eccentric, and communicating this to the rods, lifters, and valves. The catch piece L is moved from the acting surface of G in disconnecting, and back again in connecting, they thus forming a reciprocating trip and catch in connecting and disconnecting the valve gear. A weight or other force sufficient to close the valve, and a stop to hold the catch within the range of the engaging mechanism, should be used, (either in connexion with a fluid reservoir or otherwise,) and if not furnished by or with the valve, should be connected therewith. Other forms of valve gear, and also other forms of reciprocating trip and catch, may be substituted for those here shown without altering the character of this invention. It will be evident from the foregoing that any motion derived from any part of the engine may be substituted for the motion of the arms or wipers, provided it has motion as distinguished from the lifter motion; as, for

instance, instead of the horizontal vibratory motion of the arms or wipers, the time when the catch piece may be disconnected from the catch may be regulated by a vertical descending motion as the lifter rises; and in this case it will be by the co-operation of this independent motion with another motion that the catch G and catch piece G″ are disconnected. Other forms of adjustable mechanism than that here described may be used for the independent motion, or all may be dispensed with in the use of this invention.

Sheet No. 4 shows plan and elevation of parts, before described, (it being understood that the form and arrangement of them will depend in each case, as in this, upon the general arrangement of the valve gear,) and to which attention is particularly required, in order to understand this invention. F is a valve rod or stem to which the weight and valve are connected. L is a wiper moved by an independent motion. L′ is a spring. G is a catch. L″ is a catch piece, having a reciprocating movement in moving to and from the catch G in connecting and disconnecting.

What I claim as new and desire to secure by letters patent is, the combination of a cam, arm, or wiper, moved by an independent motion with a reciprocating trip and catch to liberate a weight, spring, or other force that acts to close a cut-off valve.

FREDERICK E. SICKELS.

Witnesses:
C. W. GEDES.
F. S. MEYER.

44 EXHIBIT O.

Reissue letters patent, No. 909, *granted to F. E. Sickels, Feb.* 21, 1860.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Frederick Ellsworth Sickels, of the city, county, and State of New York, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the character thereof, which distinguishes it from all other things before known, and of the manner of making and using the same, reference being had to the accompanying drawings, which make a part of the specification.

The nature of my invention consists in liberating a weight, spring, or other force to move a valve to cut off by the aid of an independent motion in combination with a regulating reservoir so as to facilitate a rapid closing of the valve at certain periods of the stroke. In cutting off when the lifter motion is in a state of rest, and using this motion alone to disconnect the weight in combination with a regulating reservoir to arrest the momentum, it is necessary to retard the descent of the weight and closing of the valve, thus incurring the loss of a slow closing cut-off, when it is required to act at certain periods of the

stroke, as the weight must be liberated some time before while there is yet motion on the lifter; but if an independent motion (that is, a motion not controlled by a lifter motion that approaches a state of rest as the piston approaches the middle of the cylinder) is used to aid in liberating a weight, spring, or other force, this loss may be avoided, as the weight or other force can then be liberated at the moment required, and the valve closed rapidly if a regulating reservoir is used to resist the force and momentum of the rapid moving parts; and if an adjustable mechanism is used, the rapid closing can be maintained at different parts of the stroke.

In the accompanying drawings, sheets 1, 2, and 3, three views are shown of this improvement in connection with others patented to me the same day as this, and they will be described in part, to facilitate the explanation of the improvement herein patented, notwithstanding it may be used without them. The same letters refer to the same parts in each figure. F is a valve rod or stem, having a piston or plunger attached to its upper end, operating within a reservoir A, shaped smaller at the bottom, which may confine the fluid contained therein as the plunger descends, substantially in the same manner described in the patent granted to me May 20th, 1842, so as to regulate the velocity of a falling weight connected to the stem that is sufficient to overcome all friction in closing the valve. To this rod or stem the valve must be attached. Either single, or double, or slide-valves may be used. A spring L′ has a catch piece L″ connected to it, that fits into a notch formed by the catch G, and extends beyond; which piece L″ has a curved projection S′ at the extreme end, against which the outer face of this arm or wiper L strikes, as it vibrates on its vertical axis. The outer face of this arm or wiper is parallel with its shaft or axle, and is of greater length than the motion of the lifter, so that it can act upon the curved projection on the catch piece L″, as it is carried up and down by the lifter, so as to determine the time when the weight shall close the valve. The vibratory motion of the arm or wiper L is obtained in the following manner: On its axle there is an arm W′, connected by a rod Y with a similar arm W on the upper end of a vertical shaft Q, which has a spring arm T at its lower end, (the outer end handle form,) with its under face provided with a filiet or catch to fall into the teeth on the upper face of the sector P, that vibrates on the axis of the shaft Q, and is held by means of the arms U, U, that project from two collars that turn, one on the lower end of the shaft Q, and the other on the upper end of a corresponding shaft O below it.

From one end of this sector a connecting rod R extends to one arm of a bell crank L, the other arm of which is connected by a connecting rod N with the strap M of the eccentric I, and at right angles to the eccentric rod J that operates the rock shaft C of the lifters A′, A″, so that the sector P, and the parts deriving motion from it, are moving while the lifters are in a state of rest, and therefore the liberation of the weight to close the valve can be effected when the lifter motion alone would be inefficient, and thus
45 obtain a rapid closing of the valve at this part of the stroke,

if a regulating reservoir is used to control the momentum. The shaft O, which is below, has a spring arm S similar and corresponding to the one T before described, and at its lower end an arm B′ and connecting rod C′, corresponding with the arm N and the rod Y above; and all other corresponding parts to work the cut-off valve for this end of the cylinder are substantially the same as the parts above described for the other end of the cylinder. The sector P has a plate P″ above and parallel with it, for the purpose of strength, and to act as a guard for the spring arms S, T. The face of the sector P is provided with two sets of teeth, each extending from the middle or arms U, U, to the ends, and the length of each part of the sector is such that the motion of the spring arms S, T, from one extremity to the other of the sector, shall shift the position of the cam or wipers L, and the corresponding one below, so that when the spring arms are at the outer end of the segment, the cams or wipers shall vibrate without permitting the weight to move the valve to cut-off, and by moving them towards the middle, the extent of the cut-off shall be reduced from the maximum to the minimum: that is to say, to cut off from the greatest to the least portion of the stroke.

It will be evident from the foregoing, that any motion derived from any part of the engine may be substituted for the motion of the arms or wipers, provided it has motion as distinguished from the lifter motion; as, for instance, instead of the horizontally vibratory motion of the arms or wipers, the time when the weight may be permitted to act to close the cut-off valve may be regulated by a vertical descending motion as the lifter rises, and in this case it will be by the co-operation of this independent motion with another motion that the liberation of the weight will be effected.

Other forms of adjustable mechanism than that here shown may be used for the independent motion, or all may be dispensed with in the use of this invention.

Other mechanism than the trip and catch can be used to transfer the weight from the mechanism that lifts it to a regulating reservoir that may be of any suitable form or kind to control the momentum, but the transfer mechanism should be placed as near the valve as practicable, so as to have as little friction as possible in the liberated parts to encounter in rapidly closing the valve with a regulating reservoir properly constructed to control the momentum of the rapidly moving parts.

Sheet No. 4 shows the elevation of parts before described, (it being understood that the form and arrangement of them will depend in each case, as in this, upon the general arrangement of the valve gear,) and to which attention is particularly required, in order to understand this invention. A is a regulating reservoir. L″ is a catch piece. L is a wiper, moved by an independent motion. F is the valve rod or stem to which the weight and valve are attached.

What I claim as new and desire to secure by letters patent is, liberating the closing weight or apparatus to cut off by the aid of an

independent motion in combination with a regulating reservoir to resist the force and momentum of the rapidly moving parts in cutting off.

FREDERICK E. SICKELS.

Witnesses:
C. W. GEDES.
F. S. MEYER.

46 EXHIBIT P.

Reissue letters patent No. 910, granted to F. E. Sickels, Feb. 21, 1860.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Frederick E. Sickels, of the city, county, and State of New York, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the character thereof, which distinguishes it from all other things before known, and of the manner of making and using the same, reference being had to the accompanying drawings, which make a part of this specification.

The nature of my improvement consists in the coexisting movement of two reciprocating catching pieces, each moving during a longer time than half a revolution of the main shaft of the engine, whereby a greater capacity for adjustment in opening the valve, and a greater certainty in connecting with the catch, are secured, than if one catching piece comes to a state of rest before the other moves, and each catching piece moves only during one-half the revolution of the engine, as has been the mode of operating in trip cut-offs heretofore.

In accompanying drawings, sheets Nos. 1, 2, and 3, three views are shown of this improvement in connection with others patented to me the same day as this, and they will be described in part to facilitate the explanation of the improvement herein patented, notwithstanding it may be used without them. The same letters refer to the same parts in each figure. F is a valve rod or stem, having a piston or plunger attached to its upper end, operating within a reservoir A, shaped smaller at the bottom, which may confine the fluid contained therein as the plunger descends, substantially in the same manner described in the patent granted to me May 20th, 1842, so as to regulate the velocity of a falling weight connected to the stem that is sufficient to overcome all friction in closing the valve. To this rod or stem the valve must be attached. Either single, double, or slide-valves may be used. If a weight or other force to move the valve in closing, and a stop to hold the catch within the range of the engaging mechanism, are not provided with or by the valve selected, they should be added thereto.

A spring L′ has a catch piece L″ connected to it, that fits into a notch formed by the catch G, and extends beyond; which piece L″

has a curved projection S′ at the extreme end, against which the outer face of this arm or wiper L strikes as it vibrates on its vertical axis. The outer face of this arm or wiper is parallel with its shaft or axle, and is of greater length than the motions of the lifter, so that it can act upon the curved projection upon the catch piece L″, as it is carried up and down by the lifter, so as to determine the time when the weight shall close the valve. The vibratory motion of the arm or wiper L is obtained in the following manner: On its axle there is an arm W′, connected by a rod Y with a similar arm W on the upper end of a vertical shaft Q, which has a spring arm T at its lower end, (the outer end handle form,) with its under face provided with a fillet or catch to fall into the teeth on the upper face of the sector P, that vibrates on the axis of the shaft Q, and is held by means of arms U, U, that project from two collars that turn, one on the lower end of the shaft Q, and the other on the upper of a corresponding shaft O below it.

From one end of this sector a connecting rod R extends to one arm of a bell crank L, the other arm of which is connected by a connecting rod N with the strap M of the eccentric *I*, and at right angles to the eccentric rod J that operates the rock shaft C of the lifters A′, A″, so that the sector P, and the parts deriving motion from it, are moving while the lifters are in a state of rest, and therefore the liberation of the weight to close the valve will be more rapid and can be regulated with more accuracy at this period of the stroke of the piston than if the lifter motion alone was used, which may, however, be done in connection with the invention herein patented.

The shaft O, which is below, has a spring arm S similar and corresponding to the one T before described, and at its lower end an arm B′ and connecting rod C′, corresponding with the arm N and the rod Y above; and all other corresponding parts to work the cut-off valve for this end of the cylinder are substantially the same as the parts above described for the other end of the cylinder. The sector P
47 has a plate P″ above and parallel with it, for the purpose of strength, and to act as a guard for the spring arms S, I. The face of the sector P is provided with two sets of teeth, each extending from the middle or arms U, U, to the ends, and the length of each part of the sector is such that the motion of the spring arms S, T, from one extremity to the other of the sector, shall shift the position of the arms or wiper Z, and the corresponding one below, so that when the spring arms are at the outer end of the segment, the arms or wipers shall vibrate without permitting the weight to move the valve to cut off, and by moving them towards the middle, the extent of the cut off shall be reduced from the maximum to the minimum: that is to say, to cut off the greatest to the least portion of the stroke, and it will be evident that the reciprocating catch piece can be placed to disconnect one part of the reciprocating valve motion from the other part of any convenient point on the mechanism between the source of the motion, as derived from the engine, and the valve, it being desirable, however, to place it as near the valve as practicable,

so that there will be as little friction as possible in the liberated parts to encounter in rapidly closing the valve.

It will be evident from the foregoing that any motion derived from any part of the engine may be substituted for the motion of the arms or wipers, provided it has motion distinguished from the lifter motion; as, for instance, instead of the horizontal vibratory motion of the arms or wipers, the time when the weight may be permitted to act to close the cut-off valve may be regulated by a vertical descending motion as the lifter rises, and in this case it will be by the co-operation of this independent motion with another motion that the catch and catch piece are disengaged; but any motion or motions whatever, either adjustable or otherwise, can be used to disengage the catch pieces in connection with the invention herein patented.

The catch pieces L′, L″ derive a reciprocating opening and closing motion from the valve gear, and operate to determine the admission of steam when their acting surfaces are in contact with the catches G, G′. It will be seen, by reference to the drawings Nos. 2 and 3, that, by the shape of the toes on the rock shaft C and the feet on the lifting rods, one rod is moved before the other comes to a state of rest, thereby imparting a coexisting movement to the catching pieces L″, L‴, permitting them to pass beyond the engaging points 1, 2, and to return to them to open the valve, therefore the position of these points can be shifted so as to secure the desired movement in opening the valves and keeping them open (if the catching pieces L″, L‴ are not disengaged) during one-half the revolution of the main shaft of the engine, and leaving sufficient space between the catches and the catch pieces, under the various conditions arising in practical operation, to insure the re-engagement after they have been disconnected to cut off.

And it is evident that the coexisting movement of the catch-pieces can be communicated to them by other sort of valve gear than that here shown, and any valve motion having a proper coexisting movement in any of its parts can be used to move the catch pieces. Other forms of reciprocating valve gear, and also other forms of reciprocating catch pieces, may be substituted for those here shown without altering the character of this invention.

Sheet No. 4 shows an elevation of parts, before described, it being understood that the form and arrangement of them will depend in each case, as in this, upon the general arrangement of the valve gear, and to which attention is particularly required in order to understand this invention.

C is the rock shaft, which, by the shape and position of the upper faces of its toes with relation to the shape and position of the faces of the feet on which they act, acts upon both rods at the same time, and imparts a coexisting movement to them and to the catch pieces L″, L‴.

What I claim as new and desire to secure by letters patent is,

imparting a coexisting movement to two reciprocating catch-pieces in the operation of the trip cut-off valves.

FREDERICK E. SICKELS.

Witnesses:
C. W. GEDES.
F. S. MEYER.

48 EXHIBIT Q.

Reissue letters patent, No. 911, *granted to F. E. Sickels, Feb.* 21, 1860.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Frederick Elsworth Sickels, of the city, county, and State of New York, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the character thereof, which distinguishes it from all other things before known, and the manner of making and using the same, reference being had to the accompanying drawings, which make a part of this specification.

The nature of my invention consists in an adjustable (that is, adjustable while the engine is in operation) mechanism, moved by the engine, so that by changing the relative position of the parts it will alter the time when the weight (spring or other independent force) shall close two separate moving cut-off valves, without altering the time or encountering the resistance of opening them, thereby rendering them more applicable as the main admitting valves of the engine and more easily adjustable as cut-off valves.

In the accompanying drawings, sheets No. 1, 2, and 3, three views are shown of this improvement in connection with others patented to me the same day as this, and they will be described in part, to facilitate the explanation of the improvement herein patented, notwithstanding it may be used without them. The same letters refer to the same parts in each figure. F is a valve rod or stem having a piston or plunger attached to its upper end, operating within a reservoir A, shaped smaller at the bottom, which may confine the fluid contained therein substantially in the same manner as described in the patent granted to me May 20th, 1842, so as to regulate the velocity of a falling weight connected to the stem that is sufficient to overcome all friction in closing the valve. To this rod or stem the valve must be attached. Either single, double, or slide valves may be used. A spring L′ has a catch-piece L″ connected to it, that fits into a notch formed by the catch G, and extends beyond; which piece L″ has a curved projection S′ at the extreme end, against which the outer face of the arm or wiper L strikes, as it vibrates on its vertical axis. The outer face of this arm or wiper is parallel with its shaft or axle and is of greater length than the motion of the lifter, so that it can act upon the curved

projection on the catch piece L″ as it is carried up and down by the lifter, so as to determine the time when the weight shall close the valve. The vibratory motion of the arm or wiper L is obtained in the following manner: On its axle there is an arm W, connected by a rod Y, with a similar arm W′, on the upper end of a vertical shaft Q, which has a spring arm T at its lower end (the outer end handle form,) with its under face provided with a fillet or catch to fall into the teeth on the upper end of the sector P, that vibrates on the shaft Q, that is held by means of arms U, U, that project from two collars that turn, one on the lower end of the shaft Q, and the other on the upper end of a corresponding shaft O, below it.

From one end of this sector a connecting rod R extends to one arm of a bell crank L, the other arm of which is connected by a connecting rod N, with the strap M, of the eccentric I, and at right angles to the eccentric rod J, that operates the rock shaft C, of the lifters A′, A″, so that the sector P, and the parts deriving motion from it, are moving while the lifters are in a state of rest, and therefore the liberation of the weight to close the valve will be more rapid and can be regulated with more accuracy at this period of the stroke of the piston than if this lifter motion alone was used.

The shaft O, which is below, has a spring arm S, similar and corresponding to the one T, before described, and at its lower end an arm B′, and connecting rod C′, corresponding with the arm W and the rod Y above, and all other corresponding parts to work the cut-off valve for this end of the cylinder are substantially the same as the parts above described for the other end of the cylinder. The sector P has a plate P′, above and parallel with it, for the purpose of strength and to act as a guard for the spring arms S, T. The face of the sector P is provided with two sets of teeth, each extending from the middle or arms U, U, to the ends, and the length of each part
49 of the sector is such that the motion of the spring arms S, T, from one extremity to the other of the sector shall shift the position of the arm or wiper L, and the corresponding one below, so that when the spring arms are at the outer end of the segment, the arms or wipers shall vibrate without permitting the weights or other force to move the valves to cut off, and by moving them towards the middle, the extent of the cut-off shall be reduced from the maximum to the minimum—that is to say, to cut off from the greatest to the least portion of the stroke without altering the time or transmitting the force of opening the valves.

It will be evident from the foregoing that any motion derived from any part of the engine may be substituted for the motion of the arms or wipers, provided it has motion as distinguished from the lifter motion; as for instance, instead of the horizontal vibratory motion of the arms or wipers, the time when the weight may be permitted to act to close the cut-off valve may be regulated by a vertical descending motion as the lifter rises; and in this case it will be by the cooperation of this motion with another motion that a more restricted regulation is effected, and the independent motion may be derived from any moving parts of the engine other than the lifter; that is,

the piston rod, the beam, crank, shaft, etc., and other mechanism than the connecting and disconnecting trip and catch may be used in transferring the weight from the mechanism that lifts it, to the mechanism that regulates its fall; and other mechanism than this for regulating its fall and raising it may be used, and other valve motions for opening the valves without transmitting the force to open through the adjustable mechanism may be used in carrying out this invention.

Sheet No. 4 shows the plan and elevation of parts before described (it being understood that the form and arrangement of them will depend in each case, as in this, upon the general arrangement of the valve gear) and to which attention is particularly required, in order to understand this invention. S, T, are spring arms. T is connected with its upper shaft. Q and S with its lower shaft. O, P, and P′ are the sector and guard-piece; U, U, are arms connected to bosses turning loosely on the shafts. Q and O being operated through the sector P by a connecting rod R, with a fixed motion. The relative positions of the sector with other parts of the mechanism being adjustable by changing the position of the arms S, T, in the sector S, for one valve, and T for the other, and this is readily done, as the cams, arms, or wipers are only in contact to cut off with the mechanism opening the valves at the time of determining the action of the weight and after the valves are open.

What I claim as new, and desire to secure by letters patent, is an adjusting mechanism, so arranged that the relative position of its parts, during any portion of its movement by the engine, can be changed to alter the closing action of the weight that operates the cut-offs without altering the time or encountering the resistance of opening the two separate moving cut-off valves.

FREDERICK E. SICKELS.

Witnesses:
C. W. GEDES.
F. S. MEYER.

50 *Letters patent granted to Zachariah Allen, dated March* 28, 1834.

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME, CONTAINING A DESCRIPTION IN THE WORDS OF THE SAID ZACHARIAH ALLEN HIMSELF, OF HIS IMPROVEMENT IN THE MODE OF OPERATING STEAM-ENGINES.

To all to whom these presents shall come:

Be it known that Zachariah Allen, of Providence, in the State of Rhode Island, a citizen of the United States, has made a new and useful improvement in the mode of constructing and operating steam-engines; which improvement consists in so arranging the apparatus of the steam valves as to cause the steam to pass freely from the boiler to act upon the piston, with its full pressure, during a longer or shorter period or portion of each respective stroke, to the extent which may be necessary to maintain the required equable movement of the steam-engine, instead of wasting ineffectually the force of the

steam by choking its passage through the throttle valve; which, as its name figurately implies, throttles the steam in the pipe in its progress from the boiler to the engine, in order to destroy a portion of its too active force.

By the usual mode of connecting the apparatus called the mill governor, a regulator with the throttle valve, whenever a fresh supply of fuel is added to the furnace, or a part of the load of machinery operated by the steam-engine is disengaged, in order that the increased elastic force of the steam may not impart a hurried impetus to the movements of the engine, a portion of the steam is unprofitably wasted by being "wire drawn," as it has been termed, through the contracted passage of the throttle valve.

Although, by the weight of the safety valve, a pressure of sixty pounds to the inch may be indicated to exist in the boiler, yet if the engine be operated with a diminished load of machinery, the actual useful pressure on the piston may be reduced by the throttle valve to twenty or thirty pounds to the inch. A large portion of the elastic force of the steam may be thus destroyed by the throttle valve, when nearly closed by the regulator, in order to reduce the action of the steam to a level with the diminished resistance to be overcome to preserve the equable motion of the mechanism. In this manner is fruitlessly expended the cost of generating in the boiler steam of higher pressure than may actually be used upon the piston.

By the proposed improvement the regulator would, in this case, admit the full undiminished pressure of the steam from the boiler to act upon the piston during an adequately regulated portion of each respective stroke, to accommodate the degree of action to the resistance to be overcome, to preserve the desired equable movement of the engine.

The steam, after thus occupying a part of the cylinder with its full elastic pressure upon the piston, will continue to act upon it expansively during the remainder of its stroke, and in this way will exhaust all its moving force.

When the regulator is not used, as is commonly the case on board of steamboats, by adjusting the lever by hand upon the cam A, in the annexed draft, the steam may be cut off at the discretion of the engineer. When the air-pump is attached to the steam engine to obtain the advantage of the atmospheric pressure, the proposed improvement will ensure a much more effective and economical use of the elastic and expansive power of steam.

The aforesaid improvement may be carried into effect simply by fixing upon the shaft of the crank a fly wheel, or upon any other shaft, performing one revolution for each stroke of the engine, a cam of a wedge form, as at A; whilst the end of the lever B is lifted by the ridge of this revolving cam, the opposite end of it operates by means of a connecting rod upon a valve of the same form as the common throttle valve, which it opens wide for the steam to pass from the boiler, with its full force against the piston, and when the end of the lever B drops into the hollow between the ridges of the cams,

as C, the recoil of the opposite end of the lever closes the valves instantaneously in the usual way.

To accomplish the plan of prolonging or diminishing the period of the admission of the steam upon the piston, the lever B is caused to traverse back and forth on the screw D, or upon a smooth pin at D, which serves as a fulcrum, upon which the lever vibrates.

51 The regulator is caused to act upon a pulley or cog wheel at E, which turns the screw D in the proper direction to move the lever B toward the wide end of the cam F whenever the steam-engine requires more steam to accelerate its motion, and toward the narrow point of the cam at G whenever the reverse of this effect is required. When the lever B traverses over the broad part of the cam at F, it remains elevated upon it during a longer portion of each revolution, and consequently keeps open during a longer portion of each stroke the valve for admitting the steam to act with greater power upon the piston. When, on the other hand, the movement of the engine becomes too much accelerated, the end of the lever B is moved by the regulator over the narrow part of the cam at G, upon which it rises to let the steam flash upon the piston for an instant, and then, by falling from it immediately, it closes the valve. The lever B thus vibrates by means of the regulator or otherwise over the cam A, from F to G, produces the effect of both rendering the movements of the steam-engine equable, and causes an important saving in the application of the elastic power of steam, and consequently of the fuel required to generate it.

In testimony that the above is a true specification of my said improvement as above described, I have hereunto set my hand this twenty-first day of December, A. D. 1833.

ZACHARIAH ALLEN.

Witnesses:

AMHERST EVERETT.

THOMAS WHITE.

52 *Letters patent, No. 912, granted to F. E. Sickels September 19, 1845.*

THE SCHEDULE REFERRED TO IN THESE LETTERS PATENT AND MAKING PART OF THE SAME.

To all to whom these presents shall come:

Be it known that I, Frederick Ellsworth Sickels, of the city, county, and State of New York, have invented a new and useful improvement in steam-engines, and that the following is a full, clear, and exact description of the character thereof, which distinguishes it from all other things before known, and of the manner of making and using the same, reference being had to the accompanying drawing, which makes a part of this specification.

By the method heretofore used in working an engine by hand, the weight of each lifting rod was required to be lifted by a force transmitted through the starting bar, thereby bringing great labor upon

the engineer. The improvement herein patented consists in counterbalancing the weight of the lifting rods when working the engine by hand, so that in raising them a weight in descending acts upon the ascending weight, whereby the force necessary to be transmitted through the starting bar and the labor of the engineer are greatly reduced in working the engine by hand, but permitting the lifting rods to exert their full weight in descending to overcome any friction when the engine is hooked on.

Sheet number one shows a view of this improvement in connection with other improvements, for which I have received patents dated the same day as this; but this improvement can be used without them, and it is deemed that further reference to them here will not facilitate the explanation of the improvement herein patented.

In sheets number one and two C is the rock shaft, H is the hand rock shaft. As this hand rock shaft is worked either way by hand when the engine is unhooked, the weight of the descending rod acting upon the toe of the rock shaft C assists to raise the ascending rod, thereby relieving the engineer in working the engine by hand; but when the engine is hooked on to the shaft C, the weight of the rods in descending exert their full force to overcome any opposing friction. It is evident that other forms of counterbalance may be used than that here shown; and weights may be used, either in connection with, or in substitution for, the weight of these rods without altering the character of this invention.

What I claim as new, and desire to secure by letters patent, is counterbalancing the weight of the lifting rods, so as to relieve the engineer in working the engine by hand, and so that when the engine is hooked on they will exert their full force in descending to overcome any opposing friction.

FREDERICK E. SICKELS.

Witnesses:
C. W. GEDDES.
F. S. MYERS.

53 United States circuit court, district of Connecticut.

Between GEORGE H. CORLISS, plaintiff,
and
WHEELER & WILSON MANUFACTURING Co.
and NATHANIEL WHEELER, defendants.
} In equity.

The replication of George H. Corliss, complainant, to the answer of Wheeler & Wilson Manufacturing Company and Nathaniel Wheeler, defendants, and each of them.

The repliant, saving and reserving to himself all and all manner of advantage of exception to the manifold insufficiencies of the said answer for replication thereunto, saith that he will and prove his said bill to be true, certain, and sufficient in the law, and that the said answer of the defendants, and of each of them, is uncertain, untrue, and insufficient to be replied unto by this repliant without

that; that any other matter or thing whatsoever in the said answer contained, material and effectual in the law to be replied unto, confessed and avoided, traversed or denied, is true; all which matters and things this repliant is and will be ready to aver and prove as this honorable court shall direct, and humbly prays as in and by said bill he hath already prayed.

GEORGE H. CORLISS,
By ROGER S. BALDWIN,
Solicitor and of Counsel.

DISTRICT OF CONNECTICUT, *ss:*

Cir. ct., clk's office; filed 2d March, 1860.
Attest: ALFRED BLACKMAN, *Clerk.*

---

54 EXHIBITS C, D, E, F, G, H, REFERRED TO IN THE ANSWER OF WHEELER & WILSON MANUFACTURING CO. TO THE BILL OF GEORGE H. CORLISS.

Record, Corliss *vs.* John Gorham, 2d.
" " " Dexter & Brother.
" " " Lewis P. Mead.

---

55 UNITED STATES OF AMERICA,
Rhode Island District, ss:

June term, A. D. 1853.

At a circuit court of the United States for the first circuit, begun and holden at Newport, within and for the district of Rhode Island, on the fifteenth day of June, A. D. 1853, before the Hon. Benj. R. Curtis, associate justice Supreme Court U. S., and the Hon. John Pitman, district judge R. I. dist., the following case, amongst others, was disposed of:

GEORGE H. CORLIS }
vs.
JOHN GORHAM, 2d. }

Be it remembered that at the June term, A. D. 1852, of said court the following writ and declaration were entered:

Writ.

RHODE ISLAND DISTRICT, *ss:*

[L. S.] The President of the United States of America to the marshal of said district, or to his deputy, greeting:

We command you to summon John Gorham, 2d, of the city and county of Providence, in the Rhode Island district, a citizen
56 of the State of Rhode Island, &c., and of the United States of America, manufacturer, *alias* genteman, if he may be found in your district, to answer the complaint of George H. Corlis, of

said Providence, in said district, a citizen of the said State of Rhode Island, &c., and of the United States of America, at the next circuit court to be holden at Newport, within and for the Rhode Island district, on the fifteenth day of June next ensuing the date hereof, in an action of the case: for that certain letters patent were duly issued, in the name of the United States of America, according to the acts of Congress in such case made and provided, bearing date the 10th day of March, A. D. 1849, were granted to the plaintiff for an improvement in cut-off and working the valves of steam-engines, which said letters patent were surrendered by him, and new letters patent duly issued, according to said acts of Congress, on the 13th day of May, A. D. 1857, granting to said plaintiff the full and exclusive right and liberty of making, constructing, and using, and vending to others to be used, the said improvement, for the time of fourteen years from the 10th day of March, A. D. 1849; and the said defendant, not ignorant of the premises, but contriving to injure the plaintiff in that behalf, and unlawfully to deprive him of the benefit of said patent right, did make, construct, and use on steam-engines, and did make and vend to others to be used on steam-engines, said improvement so as aforesaid invented and secured by letters patent, and have to date of plaintiff's writ continued so as aforesaid to use the same,
57 and to make and vend to others to be used the said improvement in manner as aforesaid, and have infringed said patent right of the plaintiff, contrary to the form of the statute in such case made and provided, and other wrongs to the plaintiff then and there did and committed, as by declaration to be filed in court will be fully set forth, to the damage of the plaintiff ten thousand dollars. Hereof fail not; and make true return of this writ, with your doings thereon.

Witness the Hon. Roger B. Taney, our chief justice, at said Newport, this 10th day of January, anno Domini 1852.

JOHN T. PITMAN, *Clerk.*

UNITED STATES OF AMERICA,
Rhode Island District, ss:

JANUARY 12, 1852.

Made service of the within writ by leaving a true and attested copy hereof at the last and usual place of abode of the within-named John Gorham, 2d, as commanded.

CHARLES E. NEWELL,
Dep'y U. S. Marshal.

Declaration.

RHODE ISLAND DISTRICT,
Circuit Court of the United States, ss:

June term, A. D. 1852.

George H. Corlis, of the city and county of Providence, in said Rhode Island district, a citizen of said State of Rhode Island and of

the United States of America, complains of John Gorham, 2nd,
58 of said Providence, in said district, manufacturer, *alias* gentleman, a citizen of the State of Rhode Island and of the United States of America, summoned by the marshal in an action of the case for that the said plaintiff was the original and first inventor of a certain new and useful improvement in cut-off and working the valves of steam-engines in the letters patent hereinafter mentioned and fully described, the same being a new and useful improvement in cut-off and working the valves of steam-engines, and which was not known or used before his said invention, and which was not, at the time of his application for a patent as hereinafter mentioned, in public use or on sale, with his consent or allowance; and the said plaintiff being so as aforesaid the original and first inventor thereof, and being also a citizen of the United of America, on the 10th day of March, A. D. 1849, upon his application therefor in due form of law, under the seal of the Patent Office of the United States, signed by the then Secretary of the Interior, and countersigned by the Commissioner of Patents of the United States, bearing date the day and year aforesaid, whereby there was secured to him, the said plaintiff, his heirs, administrators, and assigns, for the term of fourteen years from and after the said date of the patent, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improvement.

59 And the plaintiff further saith that afterwards doubts being entertained of the correctness and accuracy of the specification attached to said patent, and that said letters patent might be inoperative or invalid by reason of a defective or insufficient description, the said letters patent were duly surrendered on account of said defective specification; and said surrender having been accepted by the Commissioner of Patents, the said Commissioner did, in due form of law, issue to said plaintiff letters patent, bearing date on the 13th day of May, A. D. 1851, granting to said plaintiff, his heirs, administrators, and assigns, for the term of fourteen years from the 10th day of March, A. D. 1849, the full and exclusive right and liberty of making, using, constructing, and vending to others to use, the improvement claimed and described in the amended specification to the letters patent last aforesaid annexed, as by said letters patent, in court to be produced, will fully appear.

And the said plaintiff further saith that since said 10th day of March, A. D. 1849, he hath exercised and enjoyed said rights granted to him as aforesaid, and from said time has made, used, and constructed, and vended to others to be used, the said invention, to his great profit and advantage, yet the said defendant, well knowing the premises, but contriving to injure the plaintiff, on the 15th day of May, A. D. 1857, and at divers times before the date and pur-
60 chase of the plaintiff's writ, and during said term of fourteen years mentioned in said letters patent, to wit, between 13 day of May, A. D. 1851, and the 10th day of January, A. D. 1852, at said Providence, in said district, unlawfully and wrongfully, and without the consent and allowance, and against the will of the plaintiff, made,

constructed, and used on steam-engines, and vended to others to be used on steam-engines, the said invention and improvement in cut-off and working the valves of steam-engines in violation and infringement of the exclusive rights so secured to the said plaintiff by said letters patent as hereinafter set forth, and contrary to the form of the statute in such case made and provided; whereby the plaintiff has been greatly injured and deprived of great profits and advantages which he might and otherwise would have derived from said invention, and has sustained actual damages to the amount of ten thousand dollars, and by force of the statutes aforesaid an action hath accrued to the plaintiff, to have and recover of the defendant said actual damages, and such additional amount, not exceeding in the whole three times the amount of such actual damage, as the court may see fit to order and adjudge; yet the said defendant,
though often requested, hath not paid said sum of ten thou-
61 sand dollars, or any part thereof, but ever has refused, and
still does refuse, to pay the same, to the plaintiff's damage ten thousand dollars, as *as* laid in his writ, dated the 10th day of January, A. D. 1852; wherefore he sues by his attorney,

T. A. JENCKS.

JANUARY 20TH, 1852.

Plaintiff moves for a rule upon defendant to plead within thirty days.

T. A. JENCKS, *Pl'tff's Att'y.*

Whereupon the following notice was issued:

Notice to plead.

To John Gorham, 2d, of Providence, in said district, manufacturer, *alias* gentleman, a citizen of the State of Rhode Island and of the United States of America, or to their attorney, greeting:

On motion of Thomas A. Jencks, esq., attorney of George H. Corlis, of the city and county of Providence, in said Rhode Island district, a citizen of said State of Rhode Island and of the United States of America, plaintiff in the above entitled cause, you are hereby required to plead to the declaration now filed in court against you within thirty days from and after notice of this rule upon you. Dated Providence, January 21st, 1852.

JOHN T. PITMAN, *Clerk.*

62 UNITED STATES OF AMERICA.
Rhode Island District, ss:

JANUARY 21ST, 1852.

Made service of the within notice by delivering a true and attested copy hereof into the hands of John Gorham, 2d.

CHARLES E. NEWELL,
Deputy U. S. Marshal.

Whereupon, on the 22d day of March, A. D. 1852, the following pleas were filed:

Pleas.

And the said defendant comes and defends the wrong and injury when, &c., and says that he is not guilty of the said supposed grievances above laid to his charge in manner and form as the said pl't'ff hath in his declaration thereof complained against him. And of this he puts himself upon the country.

By his attorney, WM. H. POTTER.

In addition to all the matters proper to be given in evidence under the general issue, the said def't hereby gives notice that he will offer evidence to show that the said patentee was not the original and first inventor of a material and substantial part of the invention claimed as new, in the following words, viz: I claim the method of regulating the motion of steam-engine by means of the regulator by combining the said
63 regulator with the catches that liberate the steam valves by means of moveable cams or stops substantially as specified, or words to that effect. And that the alleged invention described and claimed in the letters patent declared on was known to the following named persons and used at the following named places before the time of the alleged invention of the said patentee, namely: that the same was before known and used in the city of Philadelphia, in the State of Pennsylvania, and elsewhere, by Cadwallader Evans, formerly of said city of Philadelphia, now of Pittsburg, in said State of Pennsylvania, and also to Lewis James, of the said city of Philadelphia, also to J. P. Morris, of the said city of Philadelphia; also, that the same was known to Frederick E. Sickels, of the city of New York, State of New York, also to Edward Bancroft, of the city of Philadelphia, in the State of Pennsylvania; also to Alfred R. Fisk, of Lancaster, in said State of Pennsylvania; also to Charles T. James, of the city of Providence, in the State of Rhode Island. Also that substantially the same thing as that claimed by the pl't'ff was first communicated and made known to him by the above-named Edward Bancroft, then a resident in the city of Providence, Rhode Island. And that the same was before described and represented in a public work published at Paris, in France, in the year A. D. 1847, entitled Traite des Machines a Vapeur,
64 par C. E. Jullien, (Treatise on Steam-engines, by C. E. Jullien,) section 2d of the text, and plate 33d. And also in another public work published in Paris, in France, in the year A. D. 1848, entitled Publicatione Industrialle des Machines, Outils et Appareels, par M. Amengould, juni, (Industrial Publications of Machines, Tools and Apparatus, by M. Amengould, jr..) especially in the 6th volume of plates, plate 1st and plate 12th, and the descriptions thereof in the corresponding part of the text. Also that the same will be found described and represented in a public work entitled Treadgold on the Steam-engine, published in London, England, vol. 1st, p. 343, plate 15. Also that the following named persons had a prior knowledge of the thing claimed as new by the pl'tiff, and that the same was before

known and used at the following named places, viz: that the same was known and used in the city of New York, State of New York, by Samuel B. Dougharty, No. 69 East 29th street, New York city; also William Shephard, No. 238 Walker street, New York city (both of the last-named persons lately worked at H. R. Cunninghams & Co., No. 100 North Moax st., New York.) Also to Josiah P. Dougherty, No. 31 Broadway, corner of Bayard street, New York city, lately worked for James Bogardus, corner of Duane and Centre streets. Also to William T. James, New Rochelle, Winchester county, State of New York. Also to William H. Pery, No. 94 Canal st., New York;

65 worked for Jno. Hoe & Co., New York.

For the purposes of trial a model will be used of the engines to which these witnesses last named will testify. Also, that the same thing was before known in the city of New York, State of New York, and used on board the steamer Rhode Island, and that the same thing was before known to Truman Cook, of Detroit, in the State of Michigan.

Also, that the same thing was before known to Henry McCollum, of the city and State of New York, and used in said city of New York. Also to Messrs. Prentiss & Pauge, of said city of New York, and there used. Also to John Gray, of steamer Bay State, running between said city of New York, and Fall River, Massachusetts.

And said def't expressly reserves the right to give other and further notices of defence down to thirty days preceeding the trial.

And the defendant will give evidence in said trial to show that the reissued letters patent, upon which the suit is brought, are not for the same invention as that specified and described in the original letters patent, surrendered by the plaintiff and intended to be patented therein, but that they contain a description and specification of another and different invention from that originally made by the plaintiff and intended to be patented by him.

WM. H. POTTER, *for Def't.*

66 And on the 14th day of May, A. D. 1852, the defendant filed the following additional notice of defence:

In addition to the matters in defence in said action, of which def't has already given notice, he hereby gives notice that substantially the same thing as that claimed by the pl't'ff in his said declaration as his invention, was before described and represented in a public work, published in London, England, entitled "The Steam-engine, Steam Navigation, and Railways, by Dr. Dyonisius Lardner," seventh edition, pages 232, 233, 234, 235, and figures and plates there referred to. And the defendant will produce and use the same on trial of said action.

Also, that the same thing, substantially, as that claimed by the plt'ff as his said invention was before described and represented in a public work, published in London, England, entitled "The London Journal and Repository of Arts, Sciences, and Manufactures," being vol. 26 and No. for Feb'y, A. D. 1845, plate 1st, and description and

trial, from pages 1 to 9, and all inclusive. And the defendant will produce and use the same on trial of said action.

By his att'y, WM. H. POTTER.

PROVIDENCE, *May* 14, 1852.

67 Upon motion of the defendant for the plaintiff to give surety for costs in said suit the following bond was filed on the 3d of July, 1852:

Bond for costs.

Know all men by these presents that we, George H. Corlis, as principal, and John Barston, as surety, both of Providence, in the county of Providence and State of Rhode Island, are firmly held and bound unto John Gorham, 2nd, of said Providence, in the sum of two thousand dollars, to be paid to him, his heirs, and assigns, to which payment we severally and jointly bind ourselves, our heirs, executors, administrators; sea'ed with our seals, and dated this 3d day of July, A. D. 1852.

The condition of the above obligation is such, that whereas s'd George H. Corlis has heretofore commenced an action of the case against the above John Gorham, 2nd, for a violation of a certain patent right, which said action is now pending in the U. S. circuit court for the Rhode Island district; and whereas a motion has been made in said case by said Gorham that said Corlis should give security for costs to said Gorham, and said Corlis has agreed to give the same: Now, if the said Corlis shall well and truly pay, or cause to be paid, to said Gorham, as defendant in said action, all such costs which said defendant may recover in said cause, and which may be taxed and allowed by said court, then this obligation is to be void; other-

68 wise to be and remain in full force and effect.

In testimony whereof, we have hereunto set our hands and seals the day and year above written.

GEO. H. CORLIS. [L. S.]
JOHN BASTON. [L. S.]

Signed, sealed, and delivered in presence of—
HENRY HUNTINGTON.

On motion of pl't'ff new bond for costs substituted for this to enable Mr. Baston to be a witness in this cause for pl't'ff; def't waives any objection on account of the bond, and pl't'ff still requesting the court to substitute the new bond for the old, it is ordered accordingly.

J. PITMAN, *Dist. Judge.*

A new bond was accordingly filed substituting the name of Horatio R. Nightingale for that of John Baston; and the case being called for trial at the June term, A. D. 1852, of said court, it was argued by counsel and committed to the following jury, viz:

Oliver Read, foreman, Jeremiah Peabody, John Alney, Thomas Maxim, Augustus Peckham, Thomas Briggs, Henry O. Liffb, John B. Wilcox, Henry H. Cook, Daniel L. Hall, George W. Chase, Henry Oman—

Who return a verdict, which is duly affirmed, in the words following, to wit:

69 *Verdict.*

GEORGE H. CORLIS }
vs.
JOHN GORHAM, 2d. }

The jury find that the defendant is not guilty in manner and form as set forth in the plaintiff's declaration.

OLIVER READ, *Foreman.*

The jury being interrogated by the plaintiff as to the grounds of their finding, answer that they find that there is no infringement.

Whereupon the following motion for a new trial was entered:

Motion for new trial.

And now on this —— day of said June term, (Aug. 7th,) after verdict and before payment in said cause, the said plaintiff moves the court that the said verdict be set aside, and a new trial be had in said cause, because said verdict is erroneous and contrary to law and the evidence, and the weight of evidence submitted to the jury in the trial of said cause in this: That it was proved to the jury by Jabez Gorham, Gorham Hurber, William C. Hubbard, and Harvey Waters, that the said defendant had been using a steam-engine between the 13th day of May, A. D. 1851, and the date of the plaintiff's writ, with certain improvements for the regulation of the motion thereof attached thereto, which improvements were substantially represented in certain models produced by the pl'ff and by the defendant
70 in said case; and that it was proved by divers witnesses, to wit, by Peter H. Watson, Harvey Waters, William C. Hibbard, and William Raymond Lee, that the said steam-engine, with the contrivances connected therewith for the purposes of regulating the motion thereof, embraced the combinations of machinery for the purpose of regulating the motion of the steam-engine by means of the regulator, by combining the regulator with the catches that liberate the steam valves by means of movable cams or stops described in the specification annexed to the letters patent for improvements in cut-off and working the valves of steam-engines granted to the said plaintiff on the —— day of ——, A. D. 1849, and reissued on the 13th day of May, 1851, which letters patent were produced in evidence; and that the said contrivances upon the defendant's machine were an infringement of the plaintiff's said patent; and that no witness proved or was offered to prove the contrary thereof on the part of the de-

fendant, except that divers persons, to wit, Edward Bancroft, Erastus W. Smith, Frederick E. Sickels, Jesse J. and Cullen Whipple, swore that, in their opinion, the hydraulic regulator used in the defendant's machine acted upon a different principle from and regulated better than the fly-ball or centrifugal governor used and described by the plaintiff as the best variety in his patented combination.

And that it was proved by all the above-named witnesses
71 that the hydraulic regulator in the defendant's machine performed no other or different office from the centrifugal governor in the plaintiff's patented combination, to wit, to place the moveable cam or stop in a position to disengage the catches that liberate the steam valves sooner when the engine went faster and later when it went slower, for the purpose of regulating the velocity of the steam-engine, by cutting off the steam at such different parts of the stroke as might be required. And it was not proved or offered to be proved that the cams or stops or catches used in the defendant's machine performed a different office or other than the same office from the cams, stops, or catches in the plaintiff's patented combination, or were not in their combination with the regular mechanical equivalents for the cams, stops, and catches in the plaintiff's patented combination, or produced any other or different results.

And that the court charged the jury that if the hydraulic regulator in the defendant's machine performed the same office in the said combination that the fly-ball or centrifugal governor performed in the plaintiff's patented combination, whether the said regulator in the defendant's machine performed the said office in said combination better or worse than the machine of the defendant, was an infringement of the plaintiff's patent.

72 And the plaintiff avers that notwithstanding the above state of the evidence and the charge of the court, the said jury returned their verdict for the defendant, and upon being interrogated by the court upon what issue and what ground their said verdict was so rendered, the said jury made answer that they found that the defendant's machine was no infringement of the plaintiff's patent. Whereupon the said plaintiff avers that the said verdict is contrary to law as given in charge to said jury by the court, and contrary to the evidence and weight of evidence submitted to said jury on said trial.

And the said plaintiff also avers that the said verdict is contrary to law and to the evidence and the weight of evidence submitted to said jury upon all the other grounds and issues in said cause.

Wherefore the plaintiff moves that the said verdict be set aside, and a new trial be had in said cause.

By his attorney, T. A. JENCKS.

And the case being continued to the November term, A. D. 1852, it then came on to be heard upon the motion for new trial, and was argued by counsel. And the court delivered an opinion denying the

Oliver Read, foreman, Jeremiah Peabody, John Alney, Thomas Maxim, Augustus Peckham, Thomas Briggs, Henry O. Liffb, John B. Wilcox, Henry H. Cook, Daniel L. Hall, George W. Chase, Henry Oman—

Who return a verdict, which is duly affirmed, in the words following, to wit:

69 *Verdict.*

GEORGE H. CORLIS }
vs.
JOHN GORHAM, 2d. }

The jury find that the defendant is not guilty in manner and form as set forth in the plaintiff's declaration.

OLIVER READ, *Foreman.*

The jury being interrogated by the plaintiff as to the grounds of their finding, answer that they find that there is no infringement.

Whereupon the following motion for a new trial was entered:

Motion for new trial.

And now on this —— day of said June term, (Aug. 7th,) after verdict and before payment in said cause, the said plaintiff moves the court that the said verdict be set aside, and a new trial be had in said cause, because said verdict is erroneous and contrary to law and the evidence, and the weight of evidence submitted to the jury in the trial of said cause in this: That it was proved to the jury by Jabez Gorham, Gorham Hurber, William C. Hubbard, and Harvey Waters, that the said defendant had been using a steam-engine between the 13th day of May, A. D. 1851, and the date of the plaintiff's writ, with certain improvements for the regulation of the motion thereof attached thereto, which improvements were substantially represented
70 in certain models produced by the pl'ff and by the defendant in said case; and that it was proved by divers witnesses, to wit, by Peter H. Watson, Harvey Waters, William C. Hibbard, and William Raymond Lee, that the said steam-engine, with the contrivances connected therewith for the purposes of regulating the motion thereof, embraced the combinations of machinery for the purpose of regulating the motion of the steam-engine by means of the regulator, by combining the regulator with the catches that liberate the steam valves by means of movable cams or stops described in the specification annexed to the letters patent for improvements in cut-off and working the valves of steam-engines granted to the said plaintiff on the —— day of ——, A. D. 1849, and reissued on the 13th day of May, 1851, which letters patent were produced in evidence; and that the said contrivances upon the defendant's machine were an infringement of the plaintiff's said patent; and that no witness proved or was offered to prove the contrary thereof on the part of the de-

fendant, except that divers persons, to wit, Edward Bancroft, Erastus W. Smith, Frederick E. Sickels, Jesse J. and Cullen Whipple, swore that, in their opinion, the hydraulic regulator used in the defendant's machine acted upon a different principle from and regulated better than the fly-ball or centrifugal governor used and described by the plaintiff as the best variety in his patented combination.

And that it was proved by all the above-named witnesses
71 that the hydraulic regulator in the defendant's machine performed no other or different office from the centrifugal governor in the plaintiff's patented combination, to wit, to place the moveable cam or stop in a position to disengage the catches that liberate the steam valves sooner when the engine went faster and later when it went slower, for the purpose of regulating the velocity of the steam-engine, by cutting off the steam at such different parts of the stroke as might be required. And it was not proved or offered to be proved that the cams or stops or catches used in the defendant's machine performed a different office or other than the same office from the cams, stops, or catches in the plaintiff's patented combination, or were not in their combination with the regular mechanical equivalents for the cams, stops, and catches in the plaintiff's patented combination, or produced any other or different results.

And that the court charged the jury that if the hydraulic regulator in the defendant's machine performed the same office in the said combination that the fly-ball or centrifugal governor performed in the plaintiff's patented combination, whether the said regulator in the defendant's machine performed the said office in said combination better or worse than the machine of the defendant, was an infringement of the plaintiff's patent.

72 And the plaintiff avers that notwithstanding the above state of the evidence and the charge of the court, the said jury returned their verdict for the defendant, and upon being interrogated by the court upon what issue and what ground their said verdict was so rendered, the said jury made answer that they found that the defendant's machine was no infringement of the plaintiff's patent. Whereupon the said plaintiff avers that the said verdict is contrary to law as given in charge to said jury by the court, and contrary to the evidence and weight of evidence submitted to said jury on said trial.

And the said plaintiff also avers that the said verdict is contrary to law and to the evidence and the weight of evidence submitted to said jury upon all the other grounds and issues in said cause.

Wherefore the plaintiff moves that the said verdict be set aside, and a new trial be had in said cause.

By his attorney, T. A. JENCKS.

And the case being continued to the November term, A. D. 1852, it then came on to be heard upon the motion for new trial, and was argued by counsel. And the court delivered an opinion denying the

motion for new trial, and ordered judgement to be entered for the defendant upon the verdict.

And the case being further continued to the present June term, 1853, judgement was entered in accordance with the opinion of
73 the court as follows:

Judgement.

Whereupon it is considered by the court here that the defendant is not guilty of the supposed grievances as laid in the plaintiff's declaration; and that the defendant have and recover their costs of suit against the plaintiff taxed at three hundred and ninety $\frac{61}{100}$ dollars.

A true copy from the records.

Attest:

HENRY PITMAN,
Clerk Cir. C't U. S. R. I. Dis't.

74 UNITED STATES OF AMERICA,
Rhode Island District, ss:

June term, A. D. 1859.

At a circuit court of the United States, begun and holden at Newport, within and for the Rhode Island district, on the fifteenth day of June, A. D. 1859, before the Hon. John Pitman, district judge R. I. district, the following case, amongst others, was disposed of:

GEORGE H. CORLIS
vs.
SIMEON W. DEXTER *et al.*

Be it remembered that at the June term A. D. 1856 of said court the following writ and declaration were entered:

Writ.

RHODE ISLAND DISTRICT, *ss:*

[L.S.] The President of the United States of America to the marshal of said district, or to his deputy, greeting:

We command you to summon Simeon W. Dexter and Daniel S. Dexter, both of North Providence, in the county of Providence, in said Rhode Island district, both citizens of the State of Rhode Island, if they may be found in your district, to answer the complaint of George H. Corlis, of said Providence, a citizen of said State of Rhode Island, at the next circuit court, to be holden at Newport, within and for the Rhode Island district, on the fifteenth day of June next ensuing
75 the date hereof, in an action of the case; for that certain letters patent of the United States, duly issued in the name of the United States of America according to the acts of Congress in such case made and provided, dated the 10th day of March, A. D. 1849, were granted to said George H. Corlis, a citizen of the United

States, for a new and useful improvement in cut-off and working the valves of steam-engines, which letters patent were surrendered and reissued in an amended specification, according to the acts of Congress in such case made and provided, on the 13th day of May, A. D. 1857; and the said defendant, not ignorant of the premises, but contriving to injure the plaintiff in that behalf, and wrongfully to deprive him of the benefit of said patent right, and since said 13th day of May, A. D. 1851, have made and used, and vended to others to be used, the invention aforesaid, so made and secured by letters patent as aforesaid, and have to the date of the plaintiff's writ continued so as aforesaid to make and use, and vend to others to be used, the said invention and improvement so patented as aforesaid, and have infringed said patent right so secured to said plaintiff by the letters patent aforesaid, contrary to the statute in such case made and provided, and other wrongs to the plaintiff have done and committed, as by declaration to be filed in court will be fully set forth, to the damage of the plaintiff ten thousand dollars. Hereof fail not, and make true return of this writ, with your doings thereon.

74 Witness the Hon. Roger B. Taney, our chief justice, at said Providence, this twenty-first day of May, anno Domini 1856.

HENRY PITMAN, *Clerk.*

Marshal's return.

UNITED STATES OF AMERICA,
Rhode Island District, ss:

MAY 26TH, 1856.

Summoned the defendant by reading the within in their presence and hearing, as commanded.

R. CLAPP, *Dep. U. S. Marshal.*

Declaration.

George H. Corlis, of the city and county of Providence, in said Rhode Island district, a citizen of said State of Rhode Island and of the United States of America, complains of Simeon W. Dexter and Daniel S. Dexter, both of North Providence, in said district, manufacturers, alias gentlemen, and citizens of the State of Rhode Island and of the United States of America, summoned by the marshal in an action of the case, for that the said plaintiff was the original and first inventor of a certain new and useful improvement in cut-off and working the valves of steam-engines in the letters patent hereinafter mentioned and fully described, the same being a new and useful improvement in cut-off and working the valves of steam-engines, and which were not known or used before his said invention, and which was not at the time of his application for a patent, as herein-

75 after mentioned, in public use or on sale with his consent or allowance, and the said plaintiff being so as aforesaid the original and first inventor thereof, and being also a citizen of the

United States of America, on the 10th day of March, A. D. 1849, upon his application therefor in due form of law, under the seal of the Patent Office of the United States, signed by the then Secretary of the Interior, and countersigned by the Commissioner of Patents of the United States, bearing date the day and year aforesaid, whereby there was secured to him, the said plaintiff, his heirs, administrators, and assigns, for the term of fourteen years from and after the date of the patent, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improvement.

And the plaintiff further saith that afterwards, doubts being entertained of the correctness and accuracy of the specification attached to said patent, and that said letters patent might be inoperative or invalid by reason of a defective or insufficient description, the said letters patent were duly surrendered on account of said defective specification, and such surrender having been accepted by the Commissioner of Patents, the said Commissioner did, in due form of law, issue to said plaintiff letters patent bearing date on the thirteenth day of May, A. D. 1851, granting to said plaintiff, his heirs, administrators, and assigns, for the term of fourteen years from the
76 10th day of March, A. D. 1849, the full and exclusive right and liberty of making, using, constructing, and vending to others to use, the improvement claimed and described in the amended specification to the letters patent last aforesaid annexed, as by said letters patent in court to be produced will fully appear.

And the said plaintiff further saith that since said 10th day of March, A. D. 1849, he hath exercised and enjoyed said right granted to him as aforesaid, and from said time has made, used, and constructed, and vended to others to be used, the said invention, to his great profit and advantage, yet the said defendant, well knowing the premises, but contriving to injure the plaintiff, on the —— day of ———, A. D. 185 , and at divers times before the date and purchase of the plaintiff's writ, and during said term of fourteen years mentioned in said letters patent, to wit, between the 13th day of May, A. D. 1851, and the 24th day of May, A. D. 1856, at said North Providence, in said district, unlawfully, wrongfully, and without the consent and allowance and against the will of the plaintiff, made, constructed, and used in steam-engines the said invention and improvement in cut-off and working the valves of steam-engines in violation and infringement of the exclusive right so secured to the said plaintiff by said letters patent as hereinafter set forth, and contrary to
77 the form of the statute in such case made and provided, whereby the plaintiff has been greatly injured and deprived of great profits and advantages which he might and otherwise would have derived from said inventions, and has sustained actual damage to the amount of ten thousand dollars; and by force of the statute aforesaid an action had accrued to the plaintiff to have and recover of the defendant said actual damage and such additional amount, not exceeding in the whole three times the amount, of such actual damage as the court may see fit to order and adjudge.

Yet the said defendant, though often requested, hath not paid said sum of ten thousand dollars, or any part thereof; but ever has refused, and still does refuse, to pay the same, to the plaintiff's damage ten thousand dollars, as laid in his writ, dated the 24th day of May, A. D. 1856, wherefore he sues by his attorney.

T. A. JENCKS.

And on the 17th day of June, 1856, the following plea was entered:

Plea.

And the defendants in the above-entitled cause come and defend the wrong and injury when, &c., and say that they are not guilty in manner and form as the plaintiff hath above declared against them; and of this they put themselves upon the country.

By their attorney, BENJ. F. THURSTON.

78 And on the 8th day of October, 1856, the defendants filed the following:

Notice of defence.

And in addition to all matter proper to be given in evidence under the general issue, the said defendants give notice to the plaintiff that they intend to prove that the said George H. Corliss, the said plaintiff, was not the original and first inventor of a substantial and material part of the invention claimed by him as new, in the following words, to wit:

"What I claim as my invention, and desire to secure by letters patent, is, first, the method substantially as described of opening the slide valves of steam-engines by connecting the valves that govern the ports at opposite ends of the cylinder with separate arms of the rock shaft, or the mechanical equivalent thereof, so that from the motion thereof the valves that keep its port or ports closed shall move over a less space while its port or ports is closed than the one that is opening or closing the port or ports, and vice versa, while at the same time the two arms by which they are operated have the same range of motion, as described, whereby I am enabled to save much of the power heretofore required to work the slide valves of steam-engines, and by which, also, I am enabled to give greater range of motion to the valves at the periods of opening and
79 closing the ports to facilitate the induction and eduction of the steam, as specified.

"And, *lastly*, I claim the method of regulating the motion of steam engines by means of the regulator, by combining the said regulator with the catches that liberate the steam valves by means of moveable cams or stops, substantially as described."

But that *the same, before the alleged invention thereof by the said plaintiff*, was known and in public use in the cities of Philadelphia,

Pa., Providence, R. I., and elsewhere, by Cadwallader Evans, formerly of Pittsburg, in the State of Pennsylvania, but now deceased; and, also, that the same, or a substantial and material part of the same, was well known to and used by the following named persons of the several places herein named, viz:

J. P. Morris, of the city of Philadelphia, Pa.; Lewis Tours, of the firm of J. P. Morris & Co., Philadelphia, Pa.; Frederick E. Sickels, of the city, county, and State of New York; Edward Bancroft, formerly of Providence, R. I., lately of Philadelphia, but now deceased; Alfred R. Fiske, of Lancaster, but now of Shamkin, Pa.; Charles T. James, of the city and county of Providence, R. I.; Noble T. Greene, of Bridgeport, in the State of Connecticut; Cullen Whipple, of the city and county of Providence, R. I.

And that the persons above named had knowledge thereof in public use in the city of Philadelphia, in the State of Pennsyl-
80 vania; in the city of Providence, in the State of Rhode Island; in the city of New York, in the State of New York; and in Lancaster, in the State of Pennsylvania.

And the said defendants further give notice to the said plaintiff that they intend to prove a prior knowledge and use of said alleged invention, as above stated, and particularly of the part specified in the second claim above stated—on the part of the said Cadwallader Evans and Edward Bancroft, both of whom are now deceased, as above stated, by the said J. P. Morris and Louis Tours, of the said city of Philadelphia; Charles T. James, Robert L. Thurston, Gideon G. Hicks, Henry W. Gardner, and Cullen Whipple, all of said Providence; Alfred R. Fiske, of Shamkin, in the State of Pennsylvania; Noble T. Greene, of Bridgeport, in the State of Connecticut; and others.

And the defendants further give notice to the said plaintiff that they intend to prove that substantially the same thing as that claimed by the plaintiff was first communicated to him, the said plaintiff, by Edward Bancroft, then resident of said Providence, and also that they will prove the same by Cullen Whipple and Charles T. James, of said Providence, and Noble T. Greene, of said Bridgeport.

And the defendants further give notice to the said plaintiff
80 that they intend to prove that the alleged invention had been described in the following public works published anterior to the supposed discovery or invention thereof by the plaintiff, viz: In a work entitled "Traite des Machines a Vapeur, par C. E. Julien; section secaird, constitutione des machines a vapeur. (Treatise on the Steam-engine, by C. E. Julien; section second, construction of engines.) Plate 33, chap. 9 of text, machines vertical, pps. 234, 235, published in Paris, France, A. D. 1847, 1849. Librarie Leuntifique Industrille, De L. Mathers (Augusten) Tuori Malay rais 15, and also in the Publications des Industrillae des Machines Artists et Apparatus, par M. Amangaude, jr., specially in the 6th volume of plates, plate 1st and plate 12;" and on page 110 of the text, commencing: "Pour les Distribution de la Vapuer dems les Cylnders," &c., to the end of the section; and also in the "Description des machines horizontales,"

on pages 170, 171, and 172, of the same book, Paris, Chy. L. Auteur, 19 Quater Rue Saint Sebastian, L. Matheas, 15 Quac Malagnais, A. D. 1848; and also in Triegold on the Steam-Engine, published in London, England, in the year 1838, vol. 1, page 343 of the text, plate 15; and also in the Popular Lectures on Science and Art, delivered in the principal cities and towns of the United
82 States of America by Dyonysius Lardner, vol. 11; Greely & McElrath, New York, 1846, particularly at pages 477, 478, 479, of the text; and also in a certain work entitled "The Steam-Engine Explained and Illustrated," with an account of the invention and progressive improvement, and its application to navigation and railways, including a memoir of Watt, by Dyonisius Lardner, published in London, England, printed by Taylor & Watton, 28 Upper Tower street, 1840, particularly at page 234.

BENJ. F. THURSTON,
Def'ts' Attorney.

And the case being continued from said June term to the November term, 1856, the defendants enter the following additional notice of defence:

And the defendants in the above-entitled cause give notice to the plaintiff that at the trial of said cause they intend to show that his said supposed invention, or a substantial and material part of the same, was described in the following public works published prior to the time of the said alleged invention, to wit: The Practical Mechanics' and Engineers' Magazine, No. 1, 2d series, Glasgow; published at the office 48 Nelson street, and by Herbert, 88 Cheapside, London, England, in the year 1846; article, "Expansion valves." pages 165, 166, 167, 168, 189, 190, 191, 192, 245, 246, 247, 248, 269, 270, 271, 272, 273, 301, 302, 303, 304, and 305.

PROVIDENCE, *Dec. 24th*, 1856.

BENJ. F. THURSTON,
Def'ts' Attorney.

83 And the case being further continued to the June term, 1857, of said court, it is then called for trial, and committed to the following jury:

Daniel Congdon, foreman; Stephen T. Church, James M. Gifford, Henry D. Martin, George C. Barker, Philip B. Bourne, Wm. B. Brownell, Wm. H. Davis, Wm. B. Fales, Benj. C. Gladding, Jabez Manchester, Benj. Easterbrooks, jr.—

Who being unable to agree upon a verdict, they are discharged from further consideration of said cause.

And on the 21st day of September, A. D. 1857, the defendants enter the following additional notices of the defence:

The defendants in the above-entitled cause further give notice to the plaintiff that at the trial of said cause they shall put in evidence, for the purposes allowed by the 15th section of the act of Congress approved July 4th, 1836, the matter hereinafter stated: "The Steam-Engine, its Invention, and Progressive Improvement, &c., &c.," by

Thomas Tredgold, published in London, Eng., 1838, and will particularly refer to pages 227, 265, articles 483, 555; plates IX, and 84 and 85.

Traites des Machines a Vapeur, part 2, Paris, 1847, plates 22, 23, and corresponding parts of the text, giving a description of the same.

The letters patent granted to Frederick E. Sickles May 20th,
84 1842, and the letters patent granted to Frederick E. Sickels, Sept. 19, 1845, each for improvement in cut-off valve gear for steam-engines.

BENJ. F. THURSTON,
Def'ts' Attorney.

And on the seventh day of October, A. D. 1857, the defendants file the following additional notices of defence:

In addition to the matter proper to be given in evidence under the general issue, and in addition to the special matter of which notice has heretofore been given to the plaintiff, the defendant gives notice that at the trial of the above case he intends to prove that the said George H. Corlis was not the original and first inventor of a substantial and material part of the invention claimed by him as new, in the following words, to wit: "What I claim as my invention and desire to secure by letters patent is, first, the method substantially as described of operating the slide valves of steam-engines, by constructing the valves that govern the ports at opposite ends of the cylinder with separate arms, the rock shaft, or the mechanical equivalents thereof, so that from the motion thereof the valve which keeps its port or ports closed shall move over a less space while its port or ports is closed than the one that is opening its port or ports, and vice versa, while at the same time the two arms by which they are operated
85 have the same range of motion as described, whereby I am enabled to save much of the power heretofore required to work the slide valve of steam-engines, and by which, also, I am enabled to give a greater range of motion to the valves at the periods of opening and closing the ports to facilitate the induction and eduction of the steam as specified;" but that the same was before the alleged invention of the plaintiff known and in public use in the town of Fall River, in the State of Massachusetts, in the city of Providence, R. I., and in the ——— ———, South Carolina; that the same, or a substantial and material part of said invention, was well known to Noble T. Greene, then of the city of Providence, and now residing in said city, as early as the year 1845, and was by him put upon an engine at said Providence, subsequently set up at the Massachusetts steam mill in said Fall River, and also by him put upon another engine built for D. Gough & Co., Pawtucket, R. I., and subsequently sold to George Kelly, of Charleston, So. Ca., prior to the time of the alleged invention of the pl't'ffs. And the fact of such prior use and knowledge will be further proved by the said Noble T. Greene, Henry W. Gardner, now of Providence; George Copeland, of the city of New York; Robert L. Thurston; of the city of Providence, Gideon G. Hicks, of the city of Providence; Cullen Whipple, of the city of Provi-

86 dence; Arnold Peter, of the city of Providence; George Kelly, of Charleston, South Carolina; Jesse Bullock, of Cammeton, Indiana, Amaso Whitaker, of New Bedford, Massachusetts; William Batty, of Providence, R. I.; and that the same was also known to William Wright, formerly of Providence, but now of Hartford, in the State of Connecticut, prior to the alleged invention of the plaintiff, and by said Wright was made known, communicated, and explained to the said plaintiff.

B. F. THURSTON, *Def'ts' Attorney.*

And the case being further continued to the November term, 1857, is was again called for trial and committed to the following jury, viz:

Charles W. Follett, foreman; Elisha W. Appleton, Edwin Angell, Caleb G. Burrows, Bowen Briggs, Horace Gray, Rich'd M. Grayson, Wensor Hunt, Wm. G. Bennett, Enos Laphemi, Thomas Phillips, John A. Crandall—

Who, being unable to agree upon a verdict, are discharged from the further consideration of said case; and the case was further continued to the June term, 1858.

On the 10th day of May, 1858, the defendants filed the following additional notices of defence:

87 Please take notice that, in addition to the references before given to you, the defendants in the above-entitled case will read in evidence pages 220, 221 of a certain publication entitled "*Traite des Machines a Vapeur*," published in Paris, France, 1847, commencing at the words "*La force a transmittor*," on page 220, to the end of titoe iii.

PROVIDENCE, *May* 10, 1848.

BENJ. F. THURSTON, *Def'ts' Att'y.*

To THOS. A. JENCKS, *Pl'ff's Att'y.*

And at said June term, 1858, the case was again called for trial and committed to the following jury:

Wm. P. Bradford, foreman; Isaac Hall, Gilbert Bailey, James A. C. Brownell, John H. Chace, Asa Cory, Frederick M. Cottrell, Edwin G. Champlin, Paul M. Clarke, Gideon Dawley, Wm. G. Sherman, George Sawyer—

Who, being unable to agree upon a verdict, are discharged from further consideration of said case.

And the case being continued to the November term, 1858, it was again called for trial and committed to the following jury:

Samuel C. Wall, foreman; Madison W. Paine, George F. Rice, Eason L. Slocum, Elisha Smith, Philip Salisbury, James B. Tillinghast, Wm. Wilkinson, Joab Whaley, Edw'd Gladding, Joseph M. Read, Royal Mathewson—

88 Who being unable to agree upon a verdict, they are discharged from further consideration of said case.

And the case being continued to the present June term, 1859,

upon motion of the plaintiff's counsel, it was discontinued, with judgment for costs for the defendants.

Judgment.

Whereupon it is considered by the court here that the defendants have and recover of the plaintiff their costs of said suit, taxed at four hundred and seven $\frac{50}{100}$ dollars.

A true copy from the records.
Attest:

HENRY PUTNAM,
Clerk Cir. C't U. S., R. I. Dist.

UNITED STATES OF AMERICA,
89 *Rhode Island District, ss:*

June term, A. D. 1859.

At a circuit court of the United States, began and holden at Newport, within and for the Rhode Island district, on the fifteenth day of June, A. D. 1859, before the Hon. John Pitman, district judge, R. I. district, the following case, amongst others, was disposed of:

GEORGE H. CORLISS,
vs.
LEWIS P. MEADE.

Be it remembered that at the June term, A. D. 1856, of said court, the following writ and declaration were entered:

Writ.

RHODE ISLAND DISTRICT, *ss:*

[L. S.] The President of the United States of America to the marshal of said district, or to his deputy, greeting:

We command you to summon Lewis P. Mead, of the city and county of Providence, in said Rhode Island district, a citizen of the State of Rhode Island, if he may be found in your district, to answer the complaint of George H. Corliss, of said Providence, a citizen of
91 said State of Rhode Island, at the next circuit court, to be holden at Newport, within and for the Rhode Island district, on the fifteenth day of June next ensuing the date hereof, in an action of the case: for that certain letters patent of the United States, duly issued, in the name of the United States of America, according to the acts of Congress in such case made and provided, dated the 10th day of March, A. D. 1849, were granted to said George H. Corliss, a citizen of the United States, for a new and useful improvement in cut-off and working the valves of steam-engines, which letters patent were surrendered, and reissued on an amended specification, according to the acts of Congress in such case made and provided, on the thirteenth day of May, A. D. 1851; and the said defendant, not ignorant of the premises, but contriving to injure the plaintiff in that behalf, and wrongfully to deprive him of the benefit of said patent right, and since said 13th day of May, A. D. 1851, has made and

used, and vended to others to be used, the invention aforesaid, so made and secured by letters patent as aforesaid, and has to the date of the plaintiff's writ continued so as aforesaid to make and use, and vend to others to be used, the said invention and improvement, so patented as aforesaid, and has infringed said patent right, so secured to said plaintiff by the letters patent aforesaid, contrary to the statute in such case made and provided, and other wrongs to the plaintiff
97 has done and committed, as by declaration to be filed in court will be fully set forth, to the damage of the plaintiff ten thousand dollars.

Hereof fail not; and make true return of this writ, with your doings thereon.

Witness the Hon. Roger B. Taney, our chief justice, at Provideuce, this twenty-fourth day of May, anno Domini 1856.

HENRY PITMAN, *Clerk.*

Marshal's return.

UNITED STATES OF AMERICA,
Rhode Island District, ss:

MAY 26TH, 1856.

Summoned the defendant by leaving a true and attested copy of the within writ at his last and usual place of abode, as commanded.

R. CLAPP,
Dep. U. S. Marshal.

Declaration.

RHODE ISLAND DISTRICT, *ss:*

Circuit court of the United States, June term, A. D. 1856.

George H. Corliss, of the city and county of Providence, in said Rhode Island district, a citizen of said State of Rhode Island, and of the United States of America, complains of Lewis P. Mead, of said Providence, in said district, manufacturer, alias gentleman, a citizen of the State of Rhode Island, and of the United States of America, summoned by the marshal in an action of the case: for that
90 the said plaintiff was the original and first inventor of a certain new and useful improvement in cut-off and working the valves of steam-engines, in the letters patent hereinafter mentioned and fully described, the same being a new and useful improvement in cut-off and working the valves of steam-engines, and which was not known or used before his said invention, and which was not at the time of his application for a patent, as hereinafter mentioned, in public use or on sale with his consent or allowance; and the said plaintiff being so as aforesaid the original and first inventor thereof, and being also a citizen of the United States of America, on the 10th day of March, A. D. 1849, upon his application therefor in due form of law, under the seal of the Patent Office of the United States, signed by the then Secretary of the Interior, and countersigned by the Commissioner of Patents of the United States, bearing date the day and year aforesaid,

whereby there was secured to him, the said plaintiff, his heirs, administrators, and assigns, for the term of fourteen years from and after the date of the patent, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improvement. And the plaintiff further saith that afterwards, doubts being entertained of the correctness and accuracy of the specification attached to said patent, and that said letters patent
92 might be inoperative or invalid by reason of a defective or insufficient description, the said letters patent were duly surrendered on account of said defective specification; and such surrender having been accepted by the Commissioner of Patents, the said Commissioner did, in due form of law, issue to said pl'ff letters patent bearing date on the 13th day of May, A. D. 1851, granting to said pl'ff, his heirs, administrators, and assigns, for the term of fourteen years from the 10th day of March, A. D. 1849, the full and exclusive right and liberty of making, using, constructing, and vending to others to use, the improvement claimed and described in the amended specification to the letters patent last aforesaid amend, as by said letters patent in court to be produced will fully appear.

And the said pl'ff further saith that since said 10th day of March, 1849, he hath exercised and enjoyed said rights, granted to him as aforesaid, and from said time has made, used, and constructed, and vended to others to be used, the said invention, to his great profit and advantage; yet the said defendant, well knowing the premises, but contriving to injure the pl'ff in that behalf and wrongfully to deprive him of the benefit of said patent right; and since said 13th day of May, A. D. 1851, to wit, on the 14th day of May, A. D. 1851, and at divers times between said 14th day of May, A. D. 1851, to the date of pl'ff's writ, and during said term of fourteen years mentioned in said letters patent, to wit, between the said 13th day of May, 1851, to the date of said writ, unlawfully and wrongfully, and without
93 the consent and allowance, and against the will of the pl'ff, made, constructed, and used on steam-engines, and vended to others to be used on steam-engines, the said invention and improvement in cut-off and working the valves of steam-engines, in violation and infringement of the exclusive rights so secured to said plff by said letters patent, as hereinafter set forth, and contrary to the form of the statute in such case made and provided, whereby the pl'ff has been greatly injured and deprived of great profits and advantages, which he might and would otherwise have derived from said invention, and has sustained actual damage to the amount of ten thousand dollars; and by force of the statute aforesaid, an action has accrued to the pl'ff to recover of the said defendant the said actual damage, and such additional amount, not exceeding in the whole three times the amount of said actual damage, as the court may see fit to order and adjudge.

And, also, for that the said defendant, still further contriving to injure the pl'ff heretofore, to wit, at Providence, in said Rhode Island district, on the 14th day of May, A. D. 1851, and on divers days and times thereafterwards and before the date of the pl'ff's writ, and during the time of fourteen years, mentioned in said letters patent,

unlawfully and wrongfully, and without the consent and allowance, and against the will of the pl'ff, made and constructed, and vended to others to be used, the invention and improvement of the
94 pl'ff described in the letters patent in the first count in this declaration, to wit, the said defendants made and constructed, and sold to others to be used, a large number, to wit, five steam-engines containing the method of regulating the motion of steam-engines by means of the regulator, by combining the said regulator with the catches that liberate the steam valves by means of movable cams or stops, substantially as described in the specification of said letters patent, in violation and infringement of the exclusive rights so secured to said Corlis by said letters patent, and contrary to the forms of the statute in such case made and provided, whereby the pl'ff has been greatly injured and deprived of great profits and advantages which he might and would otherwise have derived from said invention, and has sustained actual damage to the amount of ten thousand dollars.

And, also, for that the said defendant, still further contriving to injure the pl'ff heretofore, to wit, on the 14th day of May, 1851, and at different times thereafterwards, and during the term of fourteen years, mentioned in said letters patent, and before the date of pl'ff's writ, to wit, between the 14th day of May, A. D. 1851, and the day of the date of the pl'ff's writ at Providence aforesaid, in said Rhode Island district, unlawfully and wrongfully, and without the consent and allowance, and against the will of the pl'ff, made and con-
95 structed and used, and vended to others to be used, a large number, to wit, five steam-engines, containing the inventions of the pl'ff in said patent described, to wit, the method substantially as described therein of operating the slide valves of steam-engines by connecting the valves that govern the ports at opposite ends of the cylender with seperate arms of the rock shaft, or the mechanical equivalents thereof, so that from the motion thereof the valve that keeps its port or ports closed shall move over a less space while its port or ports is closed than the one that is opening or closing its port or ports, and vice versa, while at the same time the two arms by which they are operated have the same range of motion as described in said specifications, whereby much of the power required to work the slide valves of steam-engines is saved, and a greater range of motion is given to the valves at the period of opening and closing their ports to facilitate the induction and eduction of the steam, and also containing the method of regulating the motion of steam-engines by means of the regulator, by combining the regulator with the catches that liberate the steam valves by means of movable cams or stops, substantially as described in said specification, in violation and infringement of the exclusive rights so secured to said Corlis by said letters patent, and contrary to the form of the statute of the United States, in such case made and provided, whereby the pl'ff has
96 been greatly injured and deprived of great profits and advantages which he might and otherwise would have derived from said invention, and has sustained actual damage to the amount of ten thousand dollars; and by force of the statute aforesaid, an action has

accrued to the pl'ff to have and recover of the defendant the said actual damage, and such additional amount not exceeding in the whole three times the amount of such actual damage as the court may see fit to order and adjudge.

Yet the said defendant, though often requested, has never paid the same, or any part thereof, but ever has and still does refuse to pay the same, to the plaintiff's damage ten thousand dollars, as laid in his writ dated the 24th day of May, A. D. 1856.

Wherefore he sues.

By his attorney, T. H. JENCKES.

And on the 17th day of June, A. D. 1856, the following plea and notice of defence were entered:

Plea.

And the defendant in the above-entitled cause comes and defends the wrong and injury when, &c., and says he is not guilty in manner and form as the pl'ff hath above declared against him; and of this he puts himself upon the country.

By his attorney, BENJ'N F. THURSTON.

98 *Notice of defence.*

And, in addition to all matters proper to be given under the general issue, the said defendant gives notice that he intends to prove that the said George H. Corlis was not the original and first inventor of a substantial and material part of the invention claimed by him as new, in the following words, to wit:

"What I claim as my invention, and desire to secure by letters patent, is, first, the method, substantially as described, of opening the slide valves of steam-engines by connecting the valves that govern the ports at opposite ends of the cylinder with separate arms of the rock shaft, or the mechanical equivalents thereof, so that, from the motion thereof, the valve that keeps its port or ports closed shall move over a less space while its port or ports is closed than the one that is opening or closing its port or ports, and *vice versa*, while at the same time the two arms by which they are operated have the same range of motion as described, whereby I am enabled to save much of the power heretofore required to work the slide valves of steam-engines, and by which, also, I am enabled to give a greater range of motion to the valves at the periods of opening and closing the ports to facilitate the induction and eduction of steam, as
99 specified; and, lastly, I claim the method of regulating the motion of steam-engines by means of the regulator, by combining the said regulator with the catches that liberate the steam valves by means of movable cams or stops, substantially as described."

But that the same was, before his supposed invention, known and used in the cities of Philadelphia, Pa.; Providence, R. I., and elsewhere, by Cadwallader Evans, formerly of Pittsburg, in the State of Pennsylvania, but now deceased; and also that the same, or a substan-

tial and material part of the same, was well known to and used by the following named persons: J. P. Morris, of the city of Philadelphia; State of Pennsylvania; Lewis Tower, of the city of Philadelphia, Frederick E. Sickels, of the city, county, and State of New York; Edward Bancroft, formerly of Philadelphia, in the State of Pennsylvania, but now deceased; Alfred B. Fiske, of Lancaster, but now of Shamokin, in the State of Pennsylvania; Charles T. James, of the city and county of Providence, State of R. I.; Noble T. Greene, of Bridgeport, in the State of Connecticut; Cullen Whipple, of the city and county of Providence, State of R. I.

And this defendant further gives notice to the said pl'ff that he intends to prove a prior knowledge of said supposed invention, as above stated, and particularly of that part specified in the
100 second claim above recited, on the part of the said Cadwallader Evans and Edward Bancroft, both of whom are now deceased, as above stated, by the said J. P. Morris, of the said city of Philadelphia; Lewis Towers, of the city of Philadelphia; Charles T. James, Henry W. Gardner, Gideon G. Hicks, Robert L. Thurston, Cullen Whipple, all of Providence, in the State of Rhode Island; Alfred R. Fiske, of Shamokin, in the State of Pennsylvania.

And the said defendant further gives notice that he intends to prove that substantially the same thing as that claimed by the plaintiff was first communicated and made known to him by Edward Bancroft, then resident of the city of Providence, in said State of Rhode Island, but now deceased, and that he will prove the same by Cullen Whipple, of the city and county of Providence; Charles T. James, of said Providence; Noble T. Greene, of Bridgeport, in the State of Connecticut.

And the defendant further gives notice to the said plaintiff that he intends to prove that his supposed invention had been described in the following public works anterior to the supposed invention or discovery thereof by the said plaintiff: Traite des Machines a Vapeur, par C. E. Jullien, section secundi, construction des machines a vapeur; Treatise on the Steam-Engine, by C. E. Jullien, plate 33, published in Paris, France, 1847. Publications des Indus-
101 tielles des Machines Outels et Apparuls, par M. Armengarde. sr., especially in the 6th vol. of plates; plate 1st and plate 12 in the description thereof in the corresponding parts of the text; Paris, 1848. Tredgold on the Steam-Engine, published in London, England, in the year 1838, vol. 1, page 343, plate 15. Popular Lectures on Science and Art, delivered in the principal cities and towns of the United States, by Dionicius Lardner, vol. II; Greeley and McElrath, New York, 1846, particularly pages 477, 478, 479 of the text. The Steam-Engine Explained and Illustrated, with an account of its invention and progressive improvement, and its application to navigation and railways, including a memoir of Watt, by Dyonicious Lardner, London, England; printed by Taylor & Watton, 28 Upper Gower street, 1840.

BENJ. F. THURSTON, *Def'ts Att'y.*

And said case being continued to the November term, A. D. 1856, of said court, the defendants enter the following additional notice of defence:

And the defendants in the above-entitled cause gives notice to the plaintiff that at the trial of said cause they intend to shew that his said supposed invention, or a substantial or material part of the same, was described in the following public work, published
102 prior to the time of said alleged invention, to wit, The Practical Mechanic and Engineer's Magazine, vol. 1, second series, Glascow, published at the office 48 Nelson street, and by Herbert, 88 Cheapside, London, England, in the year 1846; article, Expansion Valves, pages 165, 166, 167, 168, 189, 190, 191, 192, 245, 246, 247, 248, 269, 270, 271, 272, 273, 301, 302, 303, 304, 305.

BENJ. F. THURSTON,
Def'ts' Attorney.

PROVIDENCE, *Dec.* 24, 1856.

And on the 21st day of September, A. D. 1857, the defendants enter the following additional notice of defence:

The defendants in the above-entitled case further give notice to the plaintiff that at the trial of said cause they shall put in evidence, for the purposes allowed in the 15th section of the act of Congress approved July 4th, 1836, the matters hereinafter stated.

"The Steam-Engine, its Invention and Progressive Improvement, &c.," by Thomas Tredgold, published in London, England, 1838, and will particularly refer to pages 227, 265, articles 483, 555, plates ix, and 84 and 85. Traite des Machines a Vapeur, part 2d, Paris, 1847; plates 22, 23, and corresponding parts of the text, giving a description of the same. The letters patent granted to Frederick E.
103 Sickels May 20, 1842, and the letters patent granted to Frederick E. Sickels, Sept. 19, 1845, each for improvement in cut-off valve geer for steam-engines.

BENJ. F. THURSTON, *Def'ts' Att'y.*

And on the 9th day of October, A. D. 1857, the defendants enter the following additional notice of defence:

In addition to the matters proper to be given in evidence under the general issue, and in addition to the special matter of which notice has heretofore been given to the plaintiff, the defendants give notice that at the trial of the above case he intends to prove that the said George H. Corlis was not the original and first inventor of a substantial and material part of the invention claimed by him as new in the following words, to wit:

"What I claim as my invention, and desire to secure by letters patent, is, first, the method substantially as described of operating the slide valves of steam-engines by connecting the valves that govern the ports at opposite ends of the cylinder with seperate arms of the rock shaft, or the mechanical equivalents thereof, so that from the motion thereof the valve which keeps its port or ports closed shall move over a less space while its port or ports is closed than the one

that is opening its port or ports, and vice versa, while at the same time the two arms by which they are operated have the same
104 range of motion as described, whereby I am enabled to save much of the power heretofore required to work the slide valves of steam-engines, and by which also I am enabled to give a greater range of motion to the valves at the periods of opening and closing the port or ports to facilitate the induction and eduction of the steam as specified;" but that the same was, before the alleged invention of the plaintiff, known and in public use in the town of Fall River, in the State of Massachusetts, in the city of Providence, R. I., and in the city of Charleston, South Carolina. That the same, or a substantial or material part of said invention, was well known to Noble T. Greene, then of the city of Providence, and now residing in said city, as early as the year 1845, and was by him put upon an engine at said Providence, subsequently set up at the Massasoit steam mills in said Fall River, and also by him put upon another engine built for D. Gough & Co., Pawtucket, R. I., and subsequently sold to George Kelly, of Charleston, S. C., prior to the time of the alleged invention of the plaintiff. And the fact of such prior use and knowledge will be further proved by the said Noble T. Greene, Henry W. Gardner, now of Providence; George Copeland, of the city of New York; Robert L. Thurston, of the city of Providence; Gideon
105 G. Hicks, of the city of Providence; Cullen Whipple, of the city of Providence; Arnold Peters, of the city of Providence; George Kelly, of Charleston, South Carolina; Jesse Bullock, of Canelton, Indiana; Amasa Whitaker, of New Bedford, Massachusetts; William Battey, of Providence, R. I.; and that the same was also known to William Wright, formerly of Providence, but now of Hartford, in the State of Connecticut, prior to the alleged invention of the plaintiff, and by said Wright was made known, communicated, and explained to the said plaintiff.

BENJ. F. THURSTON, *Def'ts' Att'y.*

And on the 13th day of May, A. D. 1858, the defendants filed the following additional notice of defence:

Please take notice that the defendants in the above-entitled case will, in addition to the references before given to you, read in evidence at the trial of said case from a certain publication entitled "Traite des Machines a Vapeur," published in Paris, France, 1847, commencing at the words, "La force a transmitter," in page 220, to the end of Titre III.

BENJ. F. THURSTON, *Def'ts' Att'y.*

To THOS. A. JENCKES, Esq., *Pl'ff's Att'y.*

And the case being continued from time to time until the
106 present June term, 1859, upon motion of the plaintiff's counsel, it was discontinued, with judgment for costs for the defendant.

Whereupon it is considered by the court here that the defendants have and recover of the plaintiff his costs of suit, taxed at fifty-eight dollars and ninety-five cents.

A true copy from the records.

Attest: HENRY PITMAN,
Clerk Cir. C't U. S., R. I. Dis't.

---

107 UNITED STATES OF AMERICA,
District of Connecticut, ss:

At a circuit court of the United States of America, within and for said district, held at Hartford, in said district, on the third Tuesday of September, A. D. 1861, and, by adjournment, at Hartford, in said district, on the 23d day of September, A. D. 1861.

Present: Honorable Samuel Nelson, one of the justices of the Supreme Court of the United States; Honorable William D. Shipman, district judge.

GEORGE H. CORLISS, complainant,
vs.
The WHEELER and WILSON MANUFACTURING COMPANY, &c., defendants. } In equity.

Circuit court of the United States for the district of Connecticut.

The cause having been heard on the pleadings and proofs, and on argument by counsel for the respective parties at the term of this court, begun and holden at Hartford on the third Tuesday of September, 1861, and the court having considered the same, and it appearing that the allegations in the complainant's bill touching the several inventions or discoveries of the complainant, and the several
108 letters patent and reissues granted to him therefor are true; and that said several reissued letters patent numbered, respectively, 763, 759, 760, and 780, were duly issued at the respective dates thereof to the complainant, as alleged in said bill, and for the inventions and improvements therein severally specified and claimed by him as the first and original inventor thereof: This court doth thereupon specially find that the claim in said letters patent, dated the 12th day of July, 1859, numbered 763, being a reissue in part of the complainant's original patent, dated the 10th day of March, 1849, in the words following, viz: "The method, substantially as described, of regulating the velocity of steam-engines by combining a regulator with a liberating valve gear," covers not only the specific arrangement and combination described in the specification, but any arrangement and combination for the purposes mentioned, which embody the ideas, principles, and mode of operation of the patentee, and that within this interpretation of the claim, in connection with the specification, the defendant's machine complained of infringes the com-

plainant's patent; that the claim in the reissued patent of the
109 same date, numbered 759, in the words following, viz: "The combination of liberating the valve gear with valves which are moved parallel to their seats, and continue their closing motion after their ports are closed, and commence their opening motion before their ports open." And the claim in the reissued patent of the same date, numbered 760, in the words following, viz: "The combination, substantially as described, of an air cushion, with the liberating valve gear of steam-engines." And the claim in the reissued patent to the complainant, dated the 26th day of July, 1859, numbered 780, in the words and figures following, viz:

"1. Combining with the rocking lever, or their equivalents, for operating the valves, the shoulders on the spring bars, or their equivalent, substantially as described and for the purpose specified."

"2. And I also claim, in combination with the shoulders on the spring bars that operate the rocking levers, substantially as described, the employment of the gauge bars, or an equivalent therefor, to regulate the period of closing the valves, whether the said guage bars be regulated by a governor or by other means as set forth," are severally for new and patentable improvements and inventions;
110 and that the defendants' machine infringes, also, each of said three last-mentioned letters patent. This court doth therefore adjudge and decree that the defendants have infringed said four several letters patent of the complainant by the use of the said several arrangements, combinations, improvements, and inventions specified and claimed therein, respectively, as aforesaid, in manner and form as charged in said bill of complaint; and that the complainant is entitled to have a perpetual injunction to restrain the defendants, their agents, servants, and all claiming or holding under or through them, from making, using, or vending, or in any manner disposing of any steam-engines or machines embracing the inventions or improvements described or claimed in said several letters patent, or either of them, or from otherwise infringing the same, and that a writ of injunction be forthwith issued therefor. And it is further adjudged and decreed that the cause be referred to Alfred Blackman, esq., a commissioner of the United States circuit court for this district, to ascertain and report the damage the complainant has sustained, or the use and profits the defendants have had and received, by reason of such infringement, since the 26th day of July,
111 A. D. 1859, the day of the issuing of the last of the said several reissue letters patent to the complainant. And upon the coming in and confirmation of the said report, that said complainant have a decree and execution for the amount found due to him, and also for the costs of this suit to be taxed.

The foregoing is a true record of the original decree.
Attest:

ALFRED BLACKMAN, *Clerk.*

A true copy of the record.
Attest: ALFRED BLACKMAN, *Clerk.*

112 UNITED STATES OF AMERICA,
District of Connecticut, ss:

At a circuit court of the United States of America within and for the district of Connecticut, held at Hartford, in said district, on the third Tuesday of September, A. D. 1861.

Present: Hon. William D. Shipman, district judge.

GEORGE H. CORLISS
vs.
THE WHEELER AND WILSON MANUFACTURING COMPANY.

And now, upon this sixth day of said term, it having been made to appear to this court that after the reference of the above-entitled cause to Alfred Blackman, esq., to take an account of the damages which the complainant has sustained as provided by the former decree in this case, the defendants consented that the sum of five hundred dollars should be taken as the amount of damages which the said complainant was entitled to recover for the causes set forth in his bill of complaint; and the complainant thereupon waived the taking of any account and the making of any report by the said master for that purpose by said former decree appointed:

Now, therefore, it is ordered, adjudged, and decreed that the said complainant have and recover from the said defendants the sum of
113 five hundred dollars as his damages, for the use on the part of the s'd defendants of the several inventions patented to the complainant, and set forth in his bill of complaint, from the date of said patents to the day of the filing of this decree, and that the complainant have his execution in common form against the said respondents for said sum.

Entered as the decree of the court, as of October 26th, A. D. 1861, being the sixth day of the said September term. And now the defendants in said cause, on this 26th day of October, A. D. 1861, appeal from said final decrees of this court to the Supreme Court of the United States of America next to be holden at Washington, in the District of Columbia, on the first Monday of December, A. D. 1861. And the said Wheeler and Wilson Manufacturing Company having filed their bond in the sum of two thousand dollars, with Philander Skidmore, of Bridgeport, in said district, as their surety, payable to the adverse party, conditioned that the appellants shall prosecute their appeal to effect and answer all damages and costs if they fail to make their plea and appeal good—

The said appeal is therefore allowed.

WILLIAM D. SHIPMAN, *Judge.*

A true copy of record.
Attest. ALFRED BLACKMAN, *Clerk.*

INDEX.

	Page.
Admission by defence	139
Construction of patents by plaintiff's counsel	260
Claims of patents in evidence	114
Cornell, Stephen—Direct	200
" Cross	203
Leslie, Edward S.—Direct	193
" Cross	197
" Redirect	199
" Recross	200
Merrill, W. H.—Direct	206
" Cross	209
Nightingale, Edward J.—Direct	211
" Cross	217
Renwick, Edward S.—Direct	115
" Cross	141
" Redirect	171
" Recalled, direct	243
" Cross	252
Stearns, William—Direct	184
" Cross	188
" Redirect	190
" Recross	191
Waters, Harvey—Direct	172
" Cross	179
" Recalled, direct	223
" Cross	234

THURSDAY, *Sept.* 20, 1860.

Mr. E. W. Stoughton, of counsel for the plaintiff, opened the case, and put in evidence the four patents following:

No. 763.—Dated July 12, 1859; reissue of patent dated March 10, 1849. For a combination of the governor with the liberating valve gear.

Claim: "The method, substantially as described, of regulating the velocity of steam-engines, by combining a regulator with a liberating valve gear."

No. 759.—Same date, same reissue. For a combination of the liberating valve gear with slide valves that overlap their ports.

Claim: "The combination of liberating valve gear with valves which are moved parallel to their seats, and continue their closing motion after their ports are closed, and commence their opening motion before their ports open, substantially as described."

No. 760.—Same date, same reissue. For the air-cushion.

Claim: "The combination, substantially as described, of an air cushion, with the liberating valve gear of steam-engines."

115 No. 780.—Dated July 26, 1859; reissue of patent dated July 29, 1851. For the operation of valves by means of rocking levers, with spring bars.

Claim: "Combining with the rocking levers, or their equivalents, for operating the valves, the shoulders on the spring bars, or their equivalents, substantially as described and for the purpose specified. And I also claim, in combination with the shoulders on the spring bars that operate the rocking levers, substantially as described, the employment of the gauge bars, or any equivalent therefor, to regulate the periods of closing the valves, whether the said gauge bars be regulated by a governor or by other means, as set forth."

Mr. Stoughton proceeded to point out to the court the parts mentioned on a brass model.

Mr. Keller: We desire the court to keep in mind that we deny their patent represents any such plan as that. Of course it is to be made out by the proofs.

Mr. Stoughton: It is understood that we produce the original patents, with the drawings, in evidence.

Adjourned to 9 o'clock to-morrow.

FRIDAY, *Sept.* 21, 1860.

The court met at 9 o'clock.

EDWARD S. RENWICK, called by the plaintiff, sworn.

Examined by Mr. Stoughton:

1 Q. State your profession, if you please.

A. My profession is that of consulting engineer.

2 Q. Have you examined the specification and drawings of Geo. H. Corliss for a combination of the regulator with a liberating valve gear?

116 A. I have examined a copy of it, sir.

3 Q. Have you examined it carefully?

A. Yes, sir.

4 Q. Are you acquainted with the machine of Mr. Corliss, as practically used, containing that arrangement?

A. I am, sir; I have seen a number of his machines in operation, and have carefully examined them.

5 Q. Have you seen them at work?

A. I have, sir.

6 Q. What improvement do you find described as the invention of Mr. Corliss in the patent to which I have referred? (No. 763.) Point out, for the purpose of making your testimony intelligible, on the models, the parts you consider described.

A. In the course of my answer I shall mention certain parts of the engine, and I shall point out these parts before I commence my answer in full. I state, in the first place, that the steam-engine has a cylinder, which is fitted with a piston, to which the steam is applied. The steam is permitted to enter that cylinder, to act upon the piston, by means of an opening at one end of the cylinder called a steam port, and it is permitted to escape when it has done its work by means of another opening called an exhaust port. This engine is a double-acting engine, adapted to act with steam pressing alternately on opposite sides of the piston; there is a steam port and an exhaust port corresponding, fitted to each end of the cylinder of the engine, in order to have the steam admitted from the boiler, or to permit it to escape from the cylinder, and a gate or valve is applied to each port. When steam is to be admitted from the boiler, the steam valve is opened; when the steam has to pass out of the cylinder, the exhaust valve is opened and the steam valve closed, because, if the steam valve and exhaust valve were both opened at once, the steam would blow directly through the steam port and out at the exhaust port. In the operation of the steam-engine the steam port is opened when the piston is ready to commence a new stroke, and steam flows in from the boiler. The flow of steam from the boiler must be shut off at least as early as the steam arrives at the end of the stroke, because the piston can move no farther. When the piston
117 commences the return stroke the exhaust port is opened, so as to let the steam escape. Now, in order to render an engine

automatic, the valves are connected with some moving part of the engine; in *this*, for example, with the crank shaft, by means of a system of mechanism of such construction that the movement of the engine itself effects the opening and closing of the valves at the proper time, so that the engine is self-acting, in contradistinction to having the valves opened by hand; and this mechanism, which extends from the valves to the moving part of the engine, is commonly called the valve gear.

These engines which Mr. Corliss builds are arranged and constructed to operate expansively, or by using the expansive force of steam. In order to do this an arrangement is made of the valve gear so that the steam port will be opened only during a portion of the movement of the piston, after which it is closed, thus cutting off the flow of steam from the boiler; and then, as no more steam can enter from the boiler, the remainder of the stroke of the piston is effected by the expansion of the body of steam shut up in the cylinder. For example, when the apparatus is set as now, the steam is admitted by the opening of the valve, as the piston commences its movement, and the valve continues open until the piston has got up to a certain point; then the valve is suddenly closed, cutting off the steam and letting the steam that is shut up in the cylinder exert its expansive force upon the piston for the remainder of the stroke.

Now, Mr. Corliss' invention, as I understand it, consists in the combination of the regulator with valve gear of a particular kind, commonly called detachable or liberating valve gear, in such a manner that the governor regulates the time at which this closing of the valve or cut-off by liberation takes place. In order to carry out this invention the valve gear must be made in two parts. One part of the valve gear is permanently connected with the valve, so as to move with it. This portion I now point to, extending as far as the valve, is connected with the valve, so as to move with it. The other portion of the valve gear is connected with the engine shaft while the engine is in operation, so as to always move with it. These portions of the valve gear are so adapted to each other and the
118 adjoining ends of the two are so formed as to have two acting faces, which may be placed in contact with each other or released from contact. As long as this contact continues the part of the valve gear connected with the valve is moved along with the part moved by the engine. When a release of the part connected with the valve is made from the parts connected with the engine, the valve, being no longer connected with the engine, is free to close by the employment of any other force, while the remaining part of the valve gear, united with the engine, goes on without reference to this release. That constitutes the release or liberation of the valve from the control of the engine, so that the closing of the valve is entirely independent of the working of the engine. In order to work the engine when different amounts of force are required, it is necessary that this release should take place at different points of the stroke of the piston. When doing very little work, the steam should be cut off soon, and the release sooner effected. When doing a larger

amount of work, the release should be effected after the piston has travelled a longer portion of the stroke. In order to make this variation in the release of one part of the valve gear from the other part. Mr. Corliss, in the first modification of his apparatus, described in his patent, shows a cam or variable instrument—an instrument which has the capacity to change its position with reference to other parts of the machine; and this instrument is so combined with the apparatus that when it is in one position the release of the valve will take place at one period of the stroke, and when in another position the release will take place at another portion of the stroke, so that this variable instrument controls the time at which the release or liberation of the valve from the mechanism of the engine takes place. Now, in order to carry out this invention of Mr. Corliss, the governor or regulator is connected with the variable instrument, so that the change in the position of the governor balls, by an increase or decrease of the speed of the engine, changes the position of this variable instrument, and causes the release to take place sooner or later, as the speed of the governor increases or diminishes. The governor represented in Mr. Corliss' patent is the common fly-ball gov-
119 ernor. It is an instrument in which a pair of balls are suspended from the arms of a shaft in such a manner that they are forced to revolve rapidly. As long as the speed remains constant the weight of the balls will be counteracted by the centrifugal force extending apart the balls and keeping them in a fixed position; if the speed increase, the centrifugal force being increased, while the weight remains the same, the balls will fly out farther. On the other hand, if the speed be decreased, the centrifugal force not being sufficient to keep the balls extended as they were, the balls will contract together. The balls are made to act upon what is commonly called the slide of the governor, which is this piece on which I place my hand, so that this variation of the position of the balls of the governor makes a corresponding variation in the slide, and that slide is connected with the instrument which controls the period of release of the valve from the control of the engine by liberating it.

Now, Corliss' invention consists of a combination, as I understand it, of the regulator or governor with the liberating valve gear in such a manner that the change in position of the governor by a change in the velocity changes the period at which the valve is freed from the control of the engine, and permits it to be closed by other means. The apparatus in Mr. Corliss' patent is described, first, as it is here represented, [model A,] and in that first modification the variable instrument which controls the release of the valve, so as to make the release at different times of the stroke of the engine, has the form of a helical cam, as shown here In another portion of the patent Mr. Corliss goes on to describe and suggest modifications of his variable instrument, and other parts of his valve gear, so that, as I understand it, the invention is not limited to a particular form of this variable instrument, but consists in the combination of the governor with liberating valve gear, where the valve is let loose from the control of the engine and permitted to close, the combination being such

that the period at which liberation is permitted to take place is in exact accordance with the position of the governor slide.

7 Q. You described the operation of the governor carrying the slide and stop or cam upon it. What duty has the governor to perform in the Corliss machine?

120 A. It has to set this variable instrument in the proper position to control the time at which the liberation should take place.

8 Q. What is the nature of that instrument? Is it a sensitive instrument—the governor?

A. The governor is of itself a very sensitive instrument; it depends, as I stated before, on the balance of two forces, one being the centrifugal force, and the other the weight of the balls. A slight preponderance in one or the other makes a change at once in its position.

9 Q. Is it susceptible of disturbance by forces being applied to it?

A. It is; if the parts connected with the movable portion, or slide of the governor, required a very great amount of friction to be overcome to operate them, or if very heavy, so as to require an amount of force to overcome their inertia, the governor would bet rammelled by having to exert that amount of force, and in that way have its sensitiveness diminished.

10 Q. What effect would that have on the capacity to place the stop in the right position?

A. It could not place the stop in the right position so rapidly; a long period might take place, and the speed of the engine during that period, whether increasing or diminishing, would continue to increase or decrease; the regulation would not be so perfect.

11 Q. In practical operation of the Corliss machine, the action of the governor determines the amount of steam to be taken for the next following stroke?

A. The governor has the capacity (being only connected with this variable instrument) to change rapidly, so that in case of increase or decrease of the speed of the engine, the governor being untrammelled by the necessity of exercising any very great force, can change almost instantaneously; so, for example, if it should happen that after the time the steam was cut off, and before the piston arrived at the end of the stroke, a change of speed of the engine should take place by throwing off a large portion of the work, that change in speed would immediately change the speed of the governor balls, and the governor being free to move, would change the position of the variable

121 instrument, so that on the next stroke the cut-off would take place at another point; in other words, the valve would be liberated from the control of the engine at a different part of the stroke.

12 Q. In proportion to the amount of work to be done at the next stroke?

A. It would be cut off in proportion to the speed of the engine; it would be immediately checked or reduced.

13 Q. Is the variation and adjustment done at the expense of the expansive force of the steam, or is that all saved?

A. The expansive force of the steam is saved, because the steam i

always worked in the cylinder at the pressure it comes from the boiler, and cut off sooner or later, as necessary.

14 Q. Were you acquainted with the regulation as applied to steam-engines in use at the date of the Corliss invention?

A. I have seen a number of engines in use prior to the date of Corliss' invention, with regulators upon them.

15 Q. What were those regulators?

A. The regulators I commonly saw in practice before Corliss' invention, were the fly ball regulators; they were connected with a valve placed in the steam pipe, commonly called the throttle valve.

16 Q. Did you ever see any regulator employed to regulate liberating valve gear, before Mr. Corliss' practically in use?

A. I never saw any before Mr. Corliss'.

17 Q. When variable regulation was adapted to the throttle valve, what was the practical operation of that upon the pressure of steam before it entered the cylinder?

A. The practical operation was to change the pressure of the steam before it acted upon the piston, so that the steam instead of acting uniformly with the same tension upon the piston, was made to act with less tension. For example, suppose steam got up in the boiler at a pressure of 100 lbs., and the work did not require so much force in the engine as steam of that pressure would exert, the operation of the throttle valve was to check the delivery of steam to the cylinder, so that the steam was of less tension when it acted upon the the piston than it was when in the boiler. For example, the case
122 might occur where a small amount of power was requisite, and the steam would be so throttled that it would act with a little amount of pressure, while it was actually 100 lbs., in the boiler.

18 Q. What was the effect upon the expansive force of the steam in the boiler by that throttling?

A. The tension of the steam was diminished; the whole expansive action of the steam was not obtained from it.

19. Court: Do you mean that the throttle valve not only diminished the volume, but also the tension?

A. It must be recollected that in the cases I saw, the piston was so arranged as to always move a certain portion of its stroke before the steam was cut off. If you choked the steam, as the steam had to fill the same space as before, its tension would be diminished in proportion to the space it had to fill. Suppose the throttle valve permitted only enough steam to come through to fill one-fourth of the space, as the same space had to be filled as before, the tension of the steam would be diminished in proportion.

By Mr. Stoughton:

20 Q. And then you would have the expansive force of the steam at a pressure of 25 lbs. instead of being able to use it at 100 lbs. expansive force?

A. Yes, sir.

21 Q. And you would lose the difference?

A. You would lose whatever the gain was between those two.

22 Q. Then, as I understand, the whole regulation of the engine when the governor was applied to the throttle valve, was carried on by diminishing the pressure of steam within the boiler?

A. By diminishing the tension of the steam passing from the boiler to the piston.

23 Q. That was the way the throttle valve regulated?

A. That was the way.

24 Q. Can you explain how the pressure of steam between the boiler and the piston became different about the throttle valve?

A. I will suppose, in order to explain it, that in the engine,
123 as it was used, there was no provision made to cut off the supply of steam from the boiler before the piston reached the entire end of its stroke; that is, the steam was permitted to flow into the cylinder during the entire stroke of the piston. Suppose steam got up in the boiler at 100 lbs. pressure, and being uncontrolled in the steam-pipe which connected the valve-chest with the boiler, it could flow freely through the pipe and act upon the piston. Suppose there was work enough to keep the piston from running away from the work, the steam would then act upon the piston at the same pressure as in the boiler. Now, suppose, on the other hand, that you throttled the steam, or choked this flow of steam in the steam pipe from the boiler by throttling or choking the pipe, if you thus diminished it, the steam could not flow through as fast, while the space to be filled up would be just as big as before. The property of steam is to expand and fill the space it enters into, if nothing else is there. As the steam comes through slowly, and the space is large, it goes on expanding and filling up that space; so that you might check the supply of steam sufficiently to make the cylinder be filled with steam greatly expanded, until it had an exceedingly small tension or pressure.

25 Q. Were the machines in use in which the throttle valve was employed as a regulator, machines that operated to cut off the steam?

A. Some that I saw did operate to cut off the steam.

26 Q. Let me suppose the steam in a working engine to be cut off at half stroke, and suppose that to be the fixed point at which the engine is to work, and suppose the work to vary; and suppose that fixed point, if cut off at half stroke, to be sufficient for the largest amount of work on the engine; how was the regulation carried on? Was it by changing the pressure by the throttle valve?

A. It was by changing the pressure.

27 Q. And changing it more or less as you made the orifice larger or smaller by moving the throttle valve?

A. Precisely so.

28 Q. Was it necessary so to set your cut-off that the supply of steam would be sufficient for the largest amount of work you were to do?

124 A. It was.

29 Q. And when you did the smallest amount of work you threw away the expansive force of steam?

A. Yes.

30 Q. Now, what is the usual point of cut-off adopted in the working engines of the present day?

A. In order to work economically—to use as small a quantity of coal as possible—they cut off at a small portion of the stroke; somewhere in the neighborhood of $\frac{1}{4}$, sometimes as low as $\frac{1}{8}$th stroke—that is, the steam valve is closed when the piston has travelled $\frac{1}{4}$th or $\frac{1}{8}$th. I have seen engines at work where the cut-off was even sooner, and others where the cut-off was a little more; but the general average is between $\frac{1}{4}$th and $\frac{1}{8}$th for stationary engines. For some engines I have known the cut-off carried to a greater extent—that is, to cut off after a larger portion of the stroke of the engine was accomplished.

31 Q. Is there any provision in the engine of Corliss, and if so, why, or in other engines, for the sudden closing and sudden opening of steam valves?

A. There is in these engines, and in a great many, a provision by which, through the movement of an eccentric, the valve is made to work very rapidly at the time the port is being opened. It is an advantage, so far as power is concerned, to get the pressure from the boiler upon the piston as soon as possible. It prevents the steam from being throttled in the passage.

32 Q. When you let in the steam to do its work, you want to give it as wide a port and as rapid a passage as possible?

A. That is so; and the valve ought to close as rapidly as possible, in order that only the steam that is in the cylinder should be permitted to expand.

33 Q. You have shown one mode of the stop or cam hung to the slide of the governor, for the purpose of indicating the point of detachment. Point out any other mode alluded to in the specification.

A. At line 141 of patent No. 763 there is this statement: "In the form of steam-engine delineated in fig. 2 the periods of liberating the valves may be varied by wedge-formed stops or cams substi-
125 tuted for the helical cams, and connected with the slide of the regulator, which in that case should not turn." That is a statement that, in place of this variable instrument here, the period of liberating the valve may be regulated by a wedge-formed stop connected with the slide of the regulator. [Illustrates.] I have now connected the wedge-formed stop with the slide of the regulator, by screwing it fast to this rod, which rod is connected with the slide of the regulator. As I move the regulator in one direction or the other, this wedge-formed stop is moved in connection with the slide. It does not turn; it moves up and down without turning. This rod is a mere prolongation of the slide. The wedge performs the same office that the helical cam does.

34 Q. The moving of the stop changes its relation with reference to the detachable gear?

A. It does, so that the valve is released from the control of the engine sooner or later, according to the position of that stop; and as that stop is connected with the governor, the period of release of the valve from the control of the engine is varied by the regulator.

35. Court: You mentioned, in connection with the use of the throttle valve and regulator, that there was a device to cut off the steam at any portion of the stroke of the piston.

A. Yes, sir.

36 Q. Was that a fixed position?

A. That was fixed by the hand of the engineer, without reference to the engine. In some engines there was an arrangement made by which that point could be adjusted; but it was not adjusted by the engine.

38 Q. It had no connection with the regulator?

A. In the cases I saw in use it had no connection with the regulator.

Mr. Stoughton:

38 Q. As I understand you, in the cases where the cut-off was regulated by the hand of the engineer, for the purpose of self-regulation, there was used a throttle valve?

A. There was, in those I saw in use.

39 Q. Was that the usual mode, so far as you know, of working engines?

126 A. As far as I know, that was the customary mode of working engines.

40 Q. I wish you now to turn attention to patent 780, for what I term a modification of valve gear invented by Mr. Corliss. Have you examined that specification and the drawings?

A. I have.

41 Q. Point out to the court what the mode or contrivance is which is described in that patent?

A. [Referring to brass model C.] As I understand the mechanism described in this patent, it is a mechanism for liberating valves, or a liberating valve gear. The invention consists in a combination of certain parts together; those parts are rocking arms for operating the valves and shoulders on the spring bars, or their equivalents, for operating the rocking arms. I may state that this valve gear is a liberating valve gear; that is, it has the peculiarity of liberating valve gear in being in two parts. These two parts have two acting faces, and as long as these two acting faces remain in contact the valve will be drawn open, and when those faces come out of contact, the valve being released, is permitted to close independently of the engine by a weight. Now, in this apparatus, one portion of this valve gear has a rocking arm upon it, which describes a circle. The other portion is, as you see here, a rod or bar, which is pressed towards a portion of the rocking arm by means of a spring, and engages with it so long as the valve is to be under the control of the engine; but when the valve is to be no longer under the control of the engine a separation takes place, and the valve is permitted to close independently of the other parts.

42 Q. The rocking shaft is connected with the valve?

A. Yes, sir.

43 Q. And the other portion is connected with the engine?

A. Yes, sir. The valve is shown behind; and in this model the connection between that rod and the crank of the engine is through this bent arm, this rod, this shaft, and this eccentric rod. Now, as I understand the first part of this invention, it consists of the combi-

nation of the shoulders of the spring bars with the rocking arms. The other portion of the invention is a combination with the shoulders of the spring bars, which operate the rocking levers with the
127 gauge bars, or an equivalent therefor, to regulate the period of closing the valve. You perceive that by changing the position of this gauge bar, the time at which the release takes place is varied; as arranged in this model, you do not always use the whole of the shoulder; but you might or not, as the case may be. Mr. Corliss describes these parts in his patent in connection with another invention for which he has a patent, viz: a means of imparting motion from the eccentric to the operating parts of the valve mechanism, which means is commonly known as the wrist plate. [Refers to defendant's large machine.] As I stated before, the connection between the slide bar and the eccentric in this form [model C] is through the intervention of this rod and arm. Now, in the particular engine Mr. Corliss represents in his drawing connected with this patent, (780,) the connection from the spring bar to the eccentric is made through the intervention of the wrist plate. The difference between the two is, that *this* is an arrangement in a horizontal direction, and this in a vertical. The difference between the two models [defendant's large model and model C] is, that in one case the connection between that slide bar and the eccentric is through the intervention of the wrist plate; while in this model C it is through the intervention of a series of arms and shafts, without a wrist plate. In *this* case, [model C,] as in *that*, [defendant's large model,] there is a gauge bar. You perceive here [defendant's large model] there is a piece of metal that slides in that case, and that piece of metal is in such a position as to bear against the spring bar; and *this* sliding piece here [model C] is in such a position as to bear against the spring bar.

44 Q. How is that regulated?

A. It is regulated by moving *this* slide piece; that is connected with the governor.

45 Q. It is operated by the governor?

A. Yes, sir. It is not connected in this model C. In order to connect it with the governor, there should be a connection from *this* piece of metal to the governor, as in the skeleton model there is a connection between the wedge stop and the governor.

46 Q. Is it connected on the other model with the governor?

A. No, sir.

128 47 Q. That is described in the patent as being connected with the governor, or you may regulate by hand?

A. There is this statement in the patent, at line 40: "The blocks (u u) for the two valves are secured to a sliding rod, (y,) and the latter may be connected with the governor at r, to determine by the velocity of the engine the position of the gauge bars, and hence determine the distance to which the shoulders on the spring bars may be forced outward by the springs, which will determine the period of closing the valves; and when this valve apparatus is thus combined with the governor, the mode of regulating patented by me March 10, 1849, will be embodied." That is, when this is combined with the

governor as he has described; and here, in this apparatus, when this stop is combined with the governor so as to be moved by it, why then the mode of regulation patented in March, 1849, will be embodied in the apparatus.

48 Q. Then this may be adjusted by the hand of the engineer or combined with the regulator?

A. You may do either. If you cut off the regulator, you have simply what is described as invented in this patent; if you apply the regulator, you have something more.

49 Q. Have you examined the letters patent, No. 760, for the air cushion?

A. I have examined a copy of that.

50 Court: I wish the witness would state again the two distinct parts involved in this invention.

A. The first part involved in that last patent (780) was the rocking arms and the shoulders of the spring bars; these acting faces against the rocking arms; the second was the spring bar that operates the rocking lever with the gauge bar.

51 Q. Depending on whether a longer or shorter hold is taken by the shoulder?

A. It does, in this model.

52 Q. And that is decided by the upward or downward movement of that stop?

A. The position of this gauge piece decides how long one shall hold on to the other.

53 Q. Why are they released at all?

A. They are released from this fact: The end of the rock-
129 ing arm describes a circle; the edge of this shoulder describes a line which differs from a circle; and where these two lines cross each other, liberation takes place. If they remained parallel to each other, the one edge would never get out of contact with the other; but as the two lines cross each other, liberation takes place at the place where the two lines cross.

By Mr. Stoughton:

54 Q. You say you have examined the specification and drawings of No. 760 for the air cushion?

A. I have, sir.

55 Q. What have you found there as the contrivance or invention of Mr. Corliss? Illustrate by reference to the model.

A. I find the combination of an air cushion with liberating valve gear.

56 Q. Which is the air cushion?

A. In this instance [model C] the air cushion is obtained by making this weight, which is in the form of a piston in a socket, shut upon a portion of air in the socket. There is a socket, in that block of metal, which extends nearly to the bottom, the bottom of the socket being closed; this piece of metal is fitted so as to nearly fill up that socket tightly, there being just freedom enough to move with ease. A little above the bottom of the socket there is a hole made, communicating

with the open air. The moment the piston gets below that hole, the passage of air from the socket to the exterior is cut off, the air remaining shut up in the socket underneath the weight, and being shut up, by its elastic force, it resists the pressure, and prevents the weight hitting the bottom of the socket with a slam. In a liberating valve gear, as the valves, when released, are no longer under control of the engine, they tend to move to their places with great force, on account of the weight or spring which is applied to them to produce the movement of the valve; and if nothing were applied to stop them, the motion would go on until some of the parts struck, and they would strike with a blow. In order to prevent that concussion, the air
130 cushion is introduced to prevent the parts from striking, and opposes an elastic material, being air, to prevent the parts coming violently in contact.

57 Q. Is it any part of the purpose of that air cushion to retard the movement of the valve until after it has entirely closed its port?

A. It is not, sir. This model [B] represents the air cushion in another position; the air cushion, in this form, is arranged in the same form as is described by Mr. Corliss's patent; the air cushion is made by making a socket in a block of metal, having a piston or piece of metal fitted to enter into the socket; the air cushion is made by shutting up the air between the piston and the bottom of that socket. Now, the arrangement is such, if you notice, that after the port is closed (after the valve has moved far enough to shut up the opening) the valve goes on and moves a still further distance; that is, it overlaps the port. These ports are so arranged that the air cushion does not check the movement in closing, until after the port is entirely closed.

58 Q. That is, it does not pass below the aperture that discharges the air?

A. No, sir; until the port is entirely closed, so that the valve may be permitted to shut very rapidly, and, notwithstanding that, be brought up without a slam of the parts.

59 Q. Let me turn your attention to patent 759—the combination of liberating valve gear with valves that overlap their ports. State whether you have examined that specification and drawing.

A. I have examined a copy of this specification and drawings.

60 Q. Point out to the court, if you please, what is described in the specification, and illustrated by the drawings, as the contrivance of Mr. Corliss.

A. That can be illustrated by this model [B.] which represents the valve and a sufficient amount of valve gear to show the connection of the parts. It consists in a combination of the liberating valve gear with valves that overlap their parts in closing. For example, this valve not only just comes up to the edge of the port, but goes on and continues its movement until the valve is overlapped a certain distance; there is, also, in this, a liberating valve gear, so that one portion is connected permanently with the valve and another with the
131 engine, and a release of the part connected with the valve from the part connected with the engine takes place. There

is, therefore, in this model a representation of the liberating valve gear and a valve which overlaps its port, thus showing the contrivance of Mr. Corliss, which is a combination of the liberating valve gear with valves that overlap their ports.

61 Q. Is there any adaptation, so to speak, in these valves to the mode of regulation adopted by Mr. Corliss in his machine; any particular capacity for regulation, as contrived by him?

A. There is this capacity: that the valve may be set rapidly in motion before it begins to admit steam into the cylinder; the opening motion may be got up before the piston is ready to receive it, so that when the piston is ready to receive it, it will receive it with great quickness; and, on the other hand, when the valve closes, the closing motion may continue with speed until the port is closed, and then may be checked after the port is closed; so that it enables you to work the steam at the best, or as nearly as possible the best, theoretical point.

62 Q. To what is that attributable?

A. To the fact of the valves sliding parallel with their seats and overlapping their ports.

63 Q. So you give a slow motion to the opening valve until it reaches the port, and then it moves with rapidity?

A. You may commence to move from the place of rest slowly and may accelerate the speed until it is as fast as required.

64 Q. What, if any, is the disadvantage of beginning to move the valve rapidly?

A. There is always a difficulty in putting any parts of metal instantaneously in rapid motion from the inertia of the parts.

65 Q. Is it more liable to fracture?

A. Yes, sir; there is more danger of fracture.

66. Court: I understand you to say it was an object to have the portion which covered the port opened rapidly?

A. Yes, sir.

67 Q. How is that accelerated motion gained?

132 A. By the peculiar form of the eccentric; it commences at a dead point, runs up to a rapid motion, and then decreases; that is common to all slide valves.

68 Q. (By Mr. Stoughton.) Look at model No. 1 (defendant's;) examine it particularly with reference to the means you find in it for regulation, and state in what manner regulation is effected in the machine represented by that model.

A. In the first place, I find in this model a liberating valve gear; that is, I find a valve gear in two parts—one of which is connected permanently with the steam-valve, and the other part connected permanently, while the engine is in operation, with the moving part of the engine; and I find that at certain times a release of the valve and the part of the mechanism connected permanently with the engine takes place, so that the valve is permitted to close independent of the control of the engine. *Here* is the part connected with the valve, commencing with the rocking arm there; the other portion of the valve gear, running from *that* piece there, which is a

movable piece, up to the eccentric, is connected permanently with the engine when in operation. When the valve is to be opened these two parts—the part connected with the valve and the one connected with the engine—move in unison, the one being carried along by the other. But at a certain time the release of the part connected with the valve from the other takes place, and the valve is then released from control of the engine, and permitted to close by other means; *here*, *this* is carried along by the eccentric, and a release takes place when the two lines cross each other; then the port is closed by a weight attached *here*, which tends always to draw the valve back on its seat. This engine, then, contains a liberating valve gear; it also has a governor, consisting of a pair of fly-balls, which, when the engine turns, are forced to turn by the operation of the engine, and will move faster or slower as the engine moves faster or slower. Then there is connected with the movable part of the governor a piece of metal which is in the form of a T; it spreads out in two directions to the right and left; when I move the balls the T is moved in a corresponding manner. Then there is the pro-
133 jection from the back of these tappets that runs upon that bar, so that the bar controls the position of the tappets, and makes their tops describe one line or another; for instance, [drawing on paper,] *that* represents a gauge bar, and *this* which I now draw represents one of these tappets or movable pieces; that movable piece has a projection on its back, which I represent by that line, which projection is underneath this gauge bar, so that the position of the gauge bar determines the position of this piece; *here* is a rocking arm, rocking upon that shaft there; the point of the rocking arm describes an arc of a circle; *this* movable piece, or tappet, is drawn along in a straight line like that. Now, the liberation of the valve gear takes place when this line crosses that line; you perceive that if this bar be moved downward it will carry the top of this tappet farther down, and then it will describe *that* dotted line, and the release will take place sooner. On the other hand, if this piece of metal be raised higher up, the point of this spring tappet will describe *that* dotted line, and the release will take place farther off, or after the piston has got to a farther point of its stroke. [Refers to model E.] This piece represents the spring tappet. Now, the part moved by the engine, acting upon the spring tappet, is not shown on this model; but if you put it on the model, and prevent the tappet from going up so far as it otherwise would, then the point of the tappet will describe a different line from what it would if permitted to go up higher, and the place where the two lines cross each other will be nearer the starting point than before. Now, in model No. 1 there is a regulator and liberating valve gear, and a combination of the two, through the intervention of this variable instrument, which determines the period at which the release of the part of the valve gear connected with the valve takes place, from the connection of the parts the movement of that variable piece, or the position in which it is set, is determined by the direction of the governor, and an immediate change of position takes place, so as to vary the time

at which the release of the valve from the control of the engine takes place.

69 Q. If you have explained the arrangement for regulation
134 on the models, move C nearer to the court, and compare the means of regulation you find in Corliss's description with the means adopted in the defendant's model?

A. This portion of the model marked D represents a piece of the valve gear of the defendant's engine—the portion of the valve gear appertaining to one steam valve, as if this sliding bar on the defendant's model No. 1 were cut in two. There is, in model D, a sliding bar corresponding with half the sliding bar in defendant's model, and that is connected with an eccentric in D, so as to be moved to and fro by the power of the engine; there is also in D a rocking arm connected with the valve, as you see *there*, which corresponds with the rocking arm on defendant's model *here*, connected by the operation of that shaft, with the valve in this chest; there is also in D a gauge bar, corresponding with that gauge bar or T-shaped piece of metal which is connected with the slide of the governor. As I move the slide of the governor, that piece is moved up and down, so that that piece or part of D corresponds with the part of the defendant's model; above that model D is another, B, which represents the valve gear I referred to as described in Mr. Corliss's patent, with the peculiarity there mentioned. Comparing the two engines together, [model A and No. 1,] it is evident, at first sight, that there are certain differences in the engine. "A" represents the engine which is shown in Mr. Corliss's drawing as a beam engine, like ordinary engines employed in steamboats; this engine of the defendants is a horizontal engine, where no beam intervenes between the engine and the crank. There are also certain other portions different; for instance, in the engine of the plaintiff there is a single eccentric used to move the steam valves and exhaust valves; in the defendant's, two eccentrics are used—one to work the steam valves and one to work the exhaust valves; so in the engine of the plaintiff is shown a wrist plate, while in the defendant's there is shown no wrist plate; in the plaintiff's, as represented in the drawings, there is a helical cam, which turns with the governor, while in the defendant's there is no helical cam shown. So, also, there are other minor points, which I do not think it worth while to mention; but when we come to a combination of parts for the purpose of regulation, I find these: I
135 find in both the defendant's and the plaintiff's a regulator; I also find in both a liberating valve gear; it is different in form in the two, but in both it has this characteristic, that there is one part of the gear connected permanently with the valve, and another connected permanently with the moving portion of the engine, and the part connected with the valve is released from the other at some time, to permit the valve to close; the engine no longer controls the movement of that valve, but lets it close as it will; and that this is applied to the valve by which steam is admitted to the cylinder. I find also an instrument which intervenes between the valve gear and

the governor or regulator, and a variation in the position of that instrument determines the closing of the valve.

70 Q. What do you call that?

A. You may call it anything. You may call it in *this engine* a gauge bar—in that a stop, or a helical cam, or when *this* mode is put on, a wedge-formed stop; but whatever you call it, it is a variable instrument, which intervenes between the governor and the valve gear; and the position of that variable instrument determines the period of the release of the valve from the control of the engine. I find both these things in the defendant's and the plaintiff's engine.

71 Q. Take "C" and "D" and illustrate the action of the governor, with its slide, or stop, or gauge bar, upon the two, in operation, for the purpose of regulation.

A. In order to do that, I must suppose that the gauge bar in C is connected with the slide of the governor, so as to be moved by the slide.

72 Q. In the patent which describes that mode, is it said it may be connected?

A. It is stated that it can be connected with the governor.

73 Q. Take the two as operated by one stop and the governor.

A. As it is now adjusted a pin is placed in the slide bar, so as to be operated by the same variable instrument that operates on the tappet in D. This pin, connected with the governor, determines the point of release of the slide bar, just a the gauge bar determines the point of release of the slide bar in the rocking arm. Now, as the engine moves, we find that in both we have a rocking arm. We
136 also find in both there is a variable instrument, which is connected with the governor. We also find in both a *a* sliding piece, the acting face or shoulder of which—(in this case the shoulder being in one piece with the slide bar, and in D formed in a separate piece of metal from the slide bar)—we find that by a change in the position of this variable piece by the governor the corner of the shoulder is made to describe a different line: with the balls in one position it will describe one line; with the balls in a different position, the corner of the acting shoulder will describe a different line, and in that way will cross the arc of the circle described by the rocking arm at different points. So that we have in Corliss the shoulder, and in D we have the shoulder made to move in reference to the slide bar. In both we have an instrument which determines the period of release; and in both that instrument is connected with the governor.

74 Q. The slide bar or stop determines how far the shoulder of that tappet shall engage, and whether that is engaged more or less the valve will be sooner or later liberated?

A. That is the fact in these two models. You notice that, in order to engage, the whole bar moves *here*, while *there* only the shoulder moves.

75 Q. What is the purpose of moving that bar?

A. To open the valve to move the shoulder connecting with the

rocking arm. For instance, in E you find the shoulder moves independent of the bar. If I take my finger away here, [from the under side of the bar,] you see that, to engage, the whole bar moves. In both cases the acting shoulder moves to engage, and moves transversely to the direction to which it is moved to open the valve.

76 Q. In this connection between the governor and its variable stop and the valve gear, what is the difference between the defendant's and plaintiff's, if any, for the purpose of regulation?

A. For the purpose of regulation I do not see any substantial difference. There is a difference in the form of the parts, and some slight difference in the way in which the parts move, arising from that change in the form, but, as I understand the invention of Mr. Corliss, it is substantially embodied in both.

137 77 Q. There is a long stop or gauge bar used for the purpose of changing the relation of the shoulder to the valve lever. Will you show how that may be engaged more or less by the slide of the governor by a simple stop?

A. In C a small stop is used, and a long rubbing surface is made upon the sliding bar. It is as if the rubbing surface were transferred to the sliding bar. Instead of letting the pin of the tappet move under the stationary sliding bar, we have the moving sliding bar moving under the pin.

78 Q. So you vary the form of the stop, and still it is substantially the same thing?

A. Yes; still the same mode of operation substantially, throwing out little peculiarities in the formation of the parts.

79 Q. Now, we pass from the subject of regulation to the modification of the valve gear, as illustrated on C, patent 780. Compare that, as described in the patent, with the defendant's valve gear, used by him, and state wherein they differ and wherein they are alike.

A. In the drawing and description that form part of that patent the invention is shown in connection with the wrist plate, such as is represented in this model, [model A,] which is the subject of a separate patent; and model C represents so much of the valve gear as I understand to be involved in patent 780. Now, there is in this a rocking lever or rocking arm, connected with the valve, and there is also a shoulder on the bar, which is caused to move to and fro by the power of the engine, and these two act in combination, so that at one time the rocking arm is dragged along and caused to open the valve, while at another time the two are released, and the valve permitted to drop. There is in the defendant's a sliding bar, which slides to and fro; that sliding bar is a piece of metal the face of which forms a shoulder, and that operates in connection with a rocking arm, so that a disconnection of the parts may take place by the surface of the shoulder passing out of contact with the face of the rocking lever.

80 Q. What is the difference between the plaintiff's and defendant's in that particular?

A. The difference between the two is this: that in the *the*

138 plaintiff's the shoulder is formed in one piece with the bar, so that the two move together; while in the defendant's the shoulder is formed on a piece of metal which is carried along with the bar, and permitted to move for engagement independent of the bar. In other words, in the plaintiff's they are made in one piece, and in the other in two.

81 Q. In one case the spring is attached to the bar, and in the other to the shoulder?

A. Yes, sir.

82 Q. Now go to the other part.

A. The other portion consists of a combination of the slide bar with the gauge bar, so that the period at which the shoulder of the slide bar passes out of contact with the shoulder of the rocking arm can be varied by changing the position of the gauge bar. It determines the period of liberation of the rocking arm from the shoulder; that is regulated, when the engine is running, by the governor. It might be applied to an engine which had no governor. This patent may be used with or without the governor.

83 Q. When it is used without the governor, how is it?

A. It is set by hand. In the defendant's you have a piece of metal called the gauge bar, which operates upon a projection upon the shoulder, and which also determines the period at which the alteration takes place.

84 Q. So that the position of that gauge bar determines period at which liberation takes place?

A. Yes.

85 Q. That is, it changes the relative position of the shoulder and rocking shaft at the time of disengagement?

A. Yes.

86 Q. Suppose you connect that gauge bar to operate with the governor, what is the difference between the operation of the machine?

A. No substantial difference, except what arises in the difference of construction of the tappets and this piece. In both you have a variable instrument, operated by the slide of the governor, for the purpose of determining the period at which your release takes place.

87 Q. Now turn attention to patent 759—the combination of liberating gear with valves that overlap their ports, and state
139 whether you find the ports described in the plaintiff's invention in the defendant's engine, as presented by that model.

A. The valve chest of this model (defendant's mode No. 1) is not open, so that we cannot see the position of the valve; but I understand a valve is used in the engine which does overlap its port; that being the case, D will represent a portion of the valve gear. Now, looking at this end, the valve opens from this side, and the valve moves some distance before the port begins to open, and after the port is closed the valve comes back some distance, so that the valve overlaps the port. Now, under the invention of Mr. Corliss there is a combination of a valve which moves parallel with its seal, as this does, and overlaps, with liberating valve gear; and, as I have shown

before, there is a liberating valve gear in the defendant's machine; there is this release of the valve from the control of the engine to permit it to close independently, and there is a valve connected with that kind of valve gear which overlaps its port or continues to move onward after the port is fairly covered.

88. Mr. Stoughton: In reference to the patent for the air-cushion, I understand you, Mr. Keller, to admit the use of substantially the same operation as is described in 760.

Mr. Keller: Oh ! certainly.

Mr. Thurston: You will, Mr. Stoughton, understand our admission is, that we use the air-cushion in combination with the kind of gear that we use. We use the air-cushion to prevent the slamming of the valve.

89 Q. (By Mr. Stoughton.) Turn your attention to the valve gear which you see in that model, and assuming the air-cushion to be used in combination with it, state whether you there find the air-cushion used in combination with liberating valve gear.

A. That depends upon what liberating valve gear is. I understand liberating valve gear to be defined by the patent in these words, at line 23: "The mechanism represented in the accompanying
140 drawings for operating the steam valves *l l* is constructed in parts, one of which is connected permanently with each valve, while the other part is connected with an eccentric, so that it is conconstantly moved by the power of the engine, while the latter is in operation." Then he goes on to say, at line 32: "The part of the valve gear connected permanently with each valve is fitted with a variable link, which is hinged to the valve rod, and has an acting face, which can be placed in contact with a corresponding face formed upon the adjacent sliding block. When these two faces are in contact, the part of the valve gear connected permanently with the valve is moved along with the remainder, so that the valve is drawn open by the power of the engine."

Now, it is very clear that the particular construction of the part of the valve gear connected with the eccentric in the defendant's differs from the particular construction represented in the plaintiff's model; but there is in both a part of the valve gear connected permanently with the valve. There is in both a part of the valve gear connected permanently with the engine. There are in both two acting faces. One acting face in the defendant's is formed upon the arm; the other is formed upon what I have termed the spring tappet. In one particular example in Corliss's patent, shown in model B, the two acting faces are one *here* and the other *there*. Now, as long as these two faces are in contact, the part that is connected with the valve will be carried along with the part connected with the engine; and when the two separate, the one is released from the other. As the two parts are connected together by acting faces that are perpendicular or thereabouts to their line of motion, the only way they can get apart is by moving one laterally to the other. That lateral movement is effected in the plaintiff, in one example, by means of a cam; in another by means of the wedge-formed stop. In *this* [defendant's model

No. 1] you obtain that result by letting the rocking arm move in a circle, so that it moves laterally. You get the separation of the two parts in one as in the other, by the lateral movement of the one acting face to the other acting face. As I understand it, these definitions determine whether you have what is described in this patent as his liberating valve gear.

141 90 Q. Do you not find that after describing one particular form of liberating valve gear, he goes on, at the top of the next page, to say that that is but an example?

A. Yes; it is stated so on line 63: "In the example thus described, the liberation of the valves, whose motions are arrested, is effected by the instrumentality of a cam, and the closing by the instrumentality of weights. These, however, constitute no part of my present invention, as the form and construction of the valve and valve gear may be varied indefinitely, as well as the means for imparting the closing movement to the valves, without changing substantially the method of arresting their movement after liberation takes place."

91 Q. In your opinion liberating valve gear is to be found in the defendant's machine?

A. I intended to state that from finding these peculiarities in both machines, which peculiarities, as I understand, define what liberating valve gear is, I find liberating valve gear in both machines.

Cross-examined by Mr. Dickerson.

92 x Q. You have been several years connected with Mr. Corliss in a professional capacity?

A. I have been employed by him professionally for several years.

93 x Q. Since about 1851?

A. I do not recollect the first date. If I recollect right, it was to examine some patent he had at the Patent Office, when I was living in Washington and practicing the profession of solicitor of patents—the same as I would be by any other person.

94 x Q. You suppose yourself, I believe, well acquainted with the theory of steam-engines?

A. I believe I am acquainted with it.

95 x Q. And with the facts that are known to engineers generally in respect to the state of the art of steam engineering?

A. I believe I understand the matter pretty well.

96 x Q. You said, I think, that before this invention of Mr. Corliss you had not seen engines in use working with the cut-off regulated by the governor?

142 A. I did state that fact, that I had not seen any mode in use except the ordinary connection of the governor with the throttle valve.

97 x Q. By which you mean to say you had not seen any engine running with the cut-off regulated by the governor prior to Corliss' invention?

A. No, sir.

98 x Q. Do you know that before Corliss' invention there were a

great many forms of regulating the steam-engine by combining the cut-off with the governor?

A. I am aware of the fact that many were described and patented.

99 x Q. You do not mean to tell the court that Mr. Corliss was the inventor or discoverer of the advantage of combining the governor with the cut-off?

A. Not broadly; but I meant to say that he was the first to combine the governor with a liberating valve gear and cut off, so that the period of release from the control of the engine was determined by the governor.

100 x Q. In the first place, Mr. Corliss, I believe, does not claim to be the inventor of this machine called the air-cushion?

A. His patent, so far as I know, is limited to the combination; he does not claim the air-cushion as a separate element for any other purpose.

101 x Q. Mr. Corliss does not profess to be the inventor of the air dash-pot?

A. Not independent of the combination.

102 x Q. Secondly, Mr. Corliss does not claim to be the inventor of this liberating valve gear?

[Mr. Curtiss objects that this is a question of law. Objection sustained.]

103 x Q. The liberating valve gear that is exhibited in that patent, I believe, was substantially well known before the date of this patent?

A. Liberating valve gear is well known now, but previous to Mr. Corliss' patent I never saw liberating valve gear like that; I saw another form of liberating valve gear, but not in that form.

143 104 x Q. That model, (No. 3—Sickles cut-off of 1845,) I believe, exhibits what you define to be a liberating valve gear?

A. Yes, sir; as I understand a liberating valve gear, it is found there.

105 x Q. You find in that model that the valve is opened by the power of the engine?

A. Yes, sir; it is opened by the power of the engine; I do not mean to say the construction of the connecting parts are the same.

106 x Q. That is an ordinary way of opening valves?

A. It is now; but before the date of this wrist motion I never saw it. The valve is opened in both cases by an eccentric through connecting mechanism.

107 x Q. When the proper time comes to release there is a wiper vibrating all the time the piston is in motion, which trips it out?

A. It effects a release of one part from the other. The valve is connected with the rod which I move up and down. The valve is inside of this chest. The valve gear is connected permanently with this rod, and *this* part here is connected permanently with the engine, so as to be moved by some moving part of the engine. Between the two there is a variable link which has an acting face that comes in contact with an acting face on the valve stem.

108 x Q. Look at model of Sickles' patent of 1842; in that case, as in No. 3, the valve is opened by the eccentric motion of the engine by contrivances well known between the two.

A. Yes, sir.

109 x Q. In this case (No. 4) the valve is liberated so as to be allowed to return by a stop put in position at the pleasure of the engineer?

A. That is so, I understand.

110 x Q. In this case the stop is stationary?

A. It is stationary, but capable of adjustment.

111 x Q. Just as in Corliss', it is stationary, but capable of adjustment?

A. Yes; but this stop (No. 4) is not connected with the governor.

144 112 x Q. In No 3 the stop or cam is in motion, and trips off the catch by a motion which is independent of the lifting motion?

A. That is the fact.

113 x Q. In the Corliss model the same arrangement exists?

A. Where the helical cam is used, the helical cam effects a disconnection of the two parts; the change in position of the cam determines the period at which disconnection takes place, sooner or later.

114 x Q. This engine (No. 4) has capacity to be adjusted to any particular place?

A. It has, by hand.

115 x Q. Model 3 exhibits the same mode of operation as the helical cam in Mr. Corliss' engine of 1849?

A. Yes.

116 x Q. In both these machines there is a dash-pot, or whatever you call it, which may be supposed to contain water, that arrests the valve at the desired point?

A. In both 3 and 4 there is a dash-pot which arrests the valve when you want to arrest it.

117 x Q. Then, in the next place, the governor for regulating the motion of engines, in various forms, is a very old contrivance?

A. Yes; that is, the governor, independent of the means by which it is made to act upon the engine; the mere governor, as an abstract mechanical element, is an old device.

118 x Q. Then we have the valve gear and the governor; now, in your examination-in-chief, you define liberating valve gear by saying that it was an organization in which one part was permanently fixed to the valve, and one part to the engine while the engine was in motion, and that at a certain point of the operation of the valve, it was allowed to be released?

A. I said that at a certain point the release of one part from the other took place, so that the valve was free to close, independently of the control of the engine; and, further, that that is a connection with the steam valve of the engine.

119 x Q. Look at No. 5; in that case the valve is lifted by a motion which is derived from the engine?

A. Yes, sir.

145 120 x Q. And is held opened by the motion to a certain point. Is that liberating valve gear in your definition?

A. *This* does not represent any engine I ever saw in use, or de-

scribed in the books; in the practical operation of this engine, as I understand, when you get round to a certain point, the valve is permitted to go down gradually to its seat by the form of the cam. *This* is not a correct representation of anything I have seen in the books. I do not understand it to be a liberating valve gear.

121 x Q. That, as you understand it, is not a liberating valve gear.

A. It is not, as I understand it, a liberating valve gear. A liberating valve gear requires that there should be a separate and independent valve at each end of the cylinder—a steam valve to admit steam into the engine; that it should be a steam valve which is liberated from the control of the engine to permit it to close. This, in No. 5, is not a steam valve. The peculiarity of Mr. Corliss' valve gear is, that the distributing steam valve is cut off, and one valve is made to perform double purposes. In No. 5 the cut-off valve is not a steam valve; but there is a steam valve having a motion of its own entirely distinct from the cut-off, and not affected by the variation of the movement of the governor; while in Corliss' engine the steam valve is liberated to close, the period of liberation depending upon the governor and controlled by it, which is not the case in No. 5.

122 x Q. I asked you if that was a liberating valve gear. You say the first distinction is, that liberating valve gear must have a valve at each end of the engine. Show us in what of Mr. Corliss' patent he so limits himself to liberating valve gear.

A. He describes his valve gear as connected at one point with the steam valve, and at another with the steam-engine.

123 x Q. Does not the engine on *this* arrangement (No. 5) give steam through *that* valve to each end of the cylinder?

A. The same valve permits steam to pass through to each end of the cylinder; but there is another valve which determines to which end of the cylinder it goes; and that is known as the steam valve of the engine.

146 124 x Q. This No. 5 would regulate the engine by determining the length of cut-off?

A. It would regulate the engine by determining the period at which the cut-off took place, the cut-off not being at the steam valve.

125 x Q. Whatever economy or advantage was due to the difference between regulating by the throttle valve and regulating by the cut-off would be exhibited on this engine as much as on Mr. Corliss'?

A. No, sir, it would not, for several reasons: First, because here the steam is not cut off at the port of the engine, and there is a certain amount of steam in the valve-chest—the passages are full of steam between the valve and the engine. There is another: That governor is connected *here* with mechanism which causes the valve to open; and as that requires a good deal of friction, the governor is hampered by having a large amount of force imposed upon it, in comparison with the work imposed upon it in Mr. Corliss' plan; therefore, the sensitiveness of the governor would be impaired; the regulation would not be so good, and the economy that would result from more perfect regulation would not be obtained.

126 x Q. You say the difference between that and the other is,

that the governor in this case is hampered, by the fact that the valve bears down on the mechanism?

A. In the first place, the mechanism must be strong enough to open the valve, which makes it bulky and heavy. In the next place, the whole strain of opening the valve comes upon that apparatus connected with the governor, and therefore tends to hamper the governor in its movement.

127 x Q. You are of opinion that the governor would not move the cam during the active lifting at all?

A. I have this opinion, that if the governor tried to move it at that time, its movement would be materially affected; in the first place, by the strain to be overcome; and in the next place, by the inertia to overcome.

128 x Q. You are of opinion that the governor would not be as sensitive in regulation as on Mr. Corliss'?

A. In the regulation I do not believe it would be as good, and the economy would certainly be less.

147 129 x Q. Is not the fact of the inferior sensitiveness of this governor due simply to the reason that in Mr. Corliss' arrangement the governor only has to control the stop, which has nothing to do with lifting the valve, whereas in this case it has to control the machine which has to lift the valve?

A. The governor has simply to change the position of that variable instrument in Corliss'—has merely to determine the position of that variable instrument. *Here* it has to move the cam, and the mechanism for opening the valve.

130 x Q. The power of the engine opens the valve in both cases?

A. Yes; but in No. 5 the apparatus is connected with the governor, so that the governor is hampered by the connection; if the governor were applied to the movable instrument, as in Mr. Corliss', that movable instrument has nothing to do with opening the valve.

131 x Q. It is only for an instant that the variable instrument is burdened with any load. During the whole of the rest of the time it is free to be moved by the governor?

A. If the governor were connected with this. I never heard of it being connected as in Mr. Corliss'.

132 x Q. That is the difference between these two in that respect?

A. There is this difference also: In this there is the liberation of a steam-valve; in No. 5 there is not the liberation of a steam-valve; the cut-off is not applied to the steam-valve at all.

133 x Q. You told the court there was a very great advantage due to the fact that the engine was regulated by the cut-off, in place of by the throttle valve, in economy?

A. There is a saving in economy; there is also in the peculiar arrangement of Mr. Corliss' an improvement in regulation.

134 x Q. The improvement in regulation in Mr. Corliss' engine depends on the fact that the variable instrument is itself unloaded.

A. Not only that, but that the change in the position of that variable instrument by the governor determines how much steam shall enter the cylinder and act upon it; my belief, from what I

148 have seen of the running of engines, is, that an engine with Mr. Corliss' regulation on it, where there is detachment of the steam-valve by the governor, will run more regularly than an engine where regulation takes place by the throttle valve.

[The court here intimated that the comparative utility of the two machines need not be inquired into at any length.

Mr. Keller thought it might have an important bearing upon another branch of the case. It might be argued upon the other side that it required invention to apply the governor to the adjustible instrument or cam of Sickles, notwithstanding it had been applied to variable instruments in Tredgold's; and it might be contended that the great gain produced by Mr. Corliss showed it required invention.

Mr. Curtis did not object to the defendants going into evidence on the question of utility; on the contrary, the plaintiff would, at some stage of the case, offer evidence (strengthening his claim to the patent) of the great practical utility of the machine, as reflecting back, and showing the advantage.]

135 x Q. Mr. Corliss has, in his engine-shop, an engine that operates on this principle?

A. I have seen there an engine operating on this principle; I have seen a large number of them.

136 x Q. That engine in the shop has got the throttle valve on it?

A. It has a screw valve, to let steam on the engine and take it off; when the engine is to be started, they open the connection between the cylinder and the boiler; in the starting of the engine it is opened widely, to admit a free passage.

137 x Q. It would be very easy, on that or any engine Mr. Corliss has running, to put the governor to the throttle valve, and make it work in the old ordinary way?

A. You might put a throttle valve in that pipe which could be combined with the governor in the old-fashioned way.

138 x Q. Has Mr. Corliss, to your knowledge, made a trial
149 to ascertain what difference would result between using his engine with the governor attached to the throttle valve, or as it is?

A. I never made the experiment, sir.

139 x Q. Did you ever know it to be made by Mr. Corliss?

A. No, sir.

140 x Q. Have you been called upon to make it at the former trials?

A. No, sir.

141 x Q. Has Mr. Corliss been called upon to make the experiment of running the engine as it now is, and comparing it with the ordinary throttle valve, with a fixed cut-off at some particular point?

A. I never saw the experiment made; I never knew it was made.

142 x Q. It could be fairly tried in two days?

A. I think not; it could be tried in a week. I do not mean to say it would not show itself in the course of a day, but I do not think it would be a fair experiment to show how much the saving was in less

than a week. If it was a considerable saving, it would show itself in the course of a day.

143 x Q. Those engines of Mr. Corliss, running throughout the country, are generally such as A?

A. The most I have seen are horizontal engines.

144 x Q. High pressure?

A. The most I have seen are very much in that form; the greater part I have seen are non-condensing engines, or commonly called high-pressure engines; I have seen them carrying steam at 60 or 80 lbs.

145 x Q. You stated, I think, the engines generally worked, cutting off from $\frac{1}{4}$ to $\frac{1}{8}$th of the stroke?

A. Yes; those I have seen were generally manufacturing engines, doing regular work. It might happen that, when doing a great press of work, the piston might be permitted to receive steam during the whole stroke, while in another case the steam would be entirely cut off—the engine running for the moment without exerting any power.

146 x Q. That is true of any throttle valve engine?

A. I never saw a throttle valve engine where the throttle valve was jammed absolutely tight.

147 x Q. If the whole load went off, the throttle valve would shut?

A. Yes; but the difference is, that whatever steam goes in in one case works expansively, where in the other it works under diminished tension.

148 x Q. I have got an engine which takes steam by a fixed cut-off at a quarter stroke, and a throttle valve governor on the outside, which has capacity to reduce the tension in the ordinary way. I want to ask this question: That cut-off being permanent, whether you do not get, from the use of any steam you put into that cylinder exactly the same proportion of power to the quantity of steam used?

A. If I understand your question, you do; the cut-off being fixed.

149 x Q. And when the governor throttles the throttle valve, it does not alter its economy, but only reduces the power?

A. When I spoke of economy, I was comparing the throttle valve, which throttles the steam, with a different apparatus, to diminish the quantity of steam taken into the engine. In order to get economy, compare the two. In the second case, in place of admitting the same bulk of steam at diminished tension, it would be only necessary to admit less than one-half the bulk at high tension to get the same effect; and by varying the period of cut-off, instead of the quantity of steam, get greater economy. When I speak of economy, it is comparatively of the two different ways of operating.

150 x Q. Now, go to the other operation. We have got a throttle valve operating on an engine, which has the capacity to reduce the tension of the boiler steam to any reduced point, of course the engine is running under the conditions of a variable load: I ask whether each stroke of that engine, the cut-off being permanent at one-quarter or one-eighth, is not performed with the same economy of fuel as any other stroke?

A. I answer that it is.

151 x Q. And therefore the fact that the steam is being wiredrawn in being let in in that organization does not alter the rate of economy on that particular engine?

A. On that particular engine it does not, if there be no change in the engine.

152 x Q. If there be any advantage it must result from the
151 fact that you change the point of cut-off in place of throttling the engine?

A. The economy results, first of all, from changing the point of cut-off instead of using the throttle valve and diminishing the tension of the steam.

153 x Q. The economy results from the fact that you get a longer or shorter rate of expansion under the several conditions of the load?

A. You work the steam expansively instead of throttling it.

154 x Q. You say your engine runs from one-quarter to one-eighth.

A. I say usually with the average load.

155 x Q. Take an ordinary mill, a cotton mill?

A. I would rather take a rolling mill, where there is a large amount of power thrown off and on.

156 x Q. I take the case of ordinary running machinery of all kinds, and the cut-off is set at one-fourth fixed permanently, which is the amount of steam necessary to do our maximum load; any regulation it wants then will be to diminish the power below the maximum load?

A. Yes, sir.

157 x Q. At one-eighth stroke it would reduce the power to about one-half?

A. Not by a considerable amount.

158 x Q. Say to two-thirds then; which is the more economical method, to throttle the engine or regulate the cut-off?

A. The most economical method is to regulate the cut-off.

159 x Q. Take an engine with 85 lbs. pressure above the atmosphere, equal to 100 lbs. of steam; we will cut off at one-fourth the stroke; the steam then would be, at the end of the stroke, 25 lbs. of mean pressure, and that steam would be 59 lbs. plus; then there is 15 lbs. of back pressure against that; that is 44 lbs. of mean pressure, cutting off at one-quarter stroke?

A. According to your calculation it is.

160 x Q. At one-eighth of the stroke the same amount will come down at the end of the stroke to 12½ lbs. pressure; the mean pressure there would be 22 lbs., taking 15 lbs. off?

A. Give me the problem, and I will work it.

161 x Q. There are cases in which there would be no gain in applying this cut-off to the governor?

152 A. I can imagine a state of facts where there might be possibly no gain, but that is not the state of facts that generally occurs in practice.

Adjourned to half past 2 p. m.

AFTERNOON SESSION.

Cross-examination of Ed. S. Renwick resumed.

Mr. Dickerson (to the court:) I was examining this witness, if your honors please, at the adjournment of the court, upon the supposed advantages that are claimed in these different patents.

Judge Nelson: It is hardly worth while to spend a great deal of time upon that. I agree that it is pertinent, but it does not enter materially into the ultimate disposition of the case.

Mr. Dickerson: I have done with that question, and I am going now to another patent, sir. In patent 759 it is claimed that Mr. Corliss is entitled to the exclusive use of "the combination of liberating valve gear with valves that are moved parallel to their seats, and continue their closing motion after their ports are closed, and commence their opening motion before their ports open, substantially as described."

162 x Q. Now, is that anything more, in plain English, than the combination of liberating valve gear with the slide valve?

A. It is more in this respect, that a slide valve might be made so as not to continue its motion after the port was closed?

163 x Q. Have you ever heard of a slide like that?

A. Yes; I heard it was put into some engine with Sickles's valve-gear.

164 x Q. Where was that?

A. I do not know the place, but I have heard it spoken of.

153 165 x Q. The usual slide valve is an instrument that overlaps its port?

A. Yes.

166 x Q. In your knowledge of engineering, have you ever seen a slide valve that did not overlap?

A. I never recollect seeing one that did not overlap.

167 x Q. Then his claim is for liberating this valve gear with the slide valve?

A. Yes.

168 x Q. But in this patent it is said (759, folio 35:) "But in order to use steam expansively with the best effect, it is necessary, and particularly in fast-moving engines, that the valve should move with rapidity in opening, so as to admit the steam at its full pressure into the cylinder, and that the valve should also move with great rapidity in closing, so as to avoid what is technically called the throttling of the steam. Now, it is obvious that the immediate starting of a valve from a state of rest into rapid motion, to effect the opening of the steam port must be attended with concussion, or at least with a severe strain upon the mechanism which actuates it, and a severe concussion must also occur in suddenly bringing the valve to rest, from a state of rapid motion, in order to effect the closing of the steam port; it has, therefore, become necessary in practice to provide for a gradually accelerated movement of lifting valves as they move from their seats

to open, and a gradually retarded movement as they are returned to their seats to close.

"Economy in the use of steam has thus been sacrificed to the necessity of obviating the inherent practical defects which attend the use of lifting valves."

Then, at line 50, he says: "And it consists in combining a slide-valve that moves beyond, or overlaps its port, with liberating valve-gear, whereby the valve, although started solely from a state of rest, will be in rapid motion when the steam-port begins to open, and although returned to a state of rest with a retarded movement, it will be in rapid motion under the action of a weight or spring, or its equivalent, at the time the port is being closed; the commencement of the opening of the port in this combination being subsequent to, instead of coincident with the commencement of the move-
154 ment of the valve, and the closing of the port being prior to the return of the liberated valve to a state of rest, instead of coincident therewith."

Then, at line 90, he says: "The valve may, therefore, be started slowly from its place of rest and be moved with gradually accelerated speed so as to attain a rapid movement at the instant it begins to uncover its port." That has been explained to the court to be of great advantage. Now, Mr. Renwick, are you familiar with the construction of large slide valve engines, such as are in common use in driving ships?

A. Yes, sir; comparatively slow-working engines of very large size.

169 x Q. Large-sized engines working some fifty or sixty turns a minute?

A. Yes, sir; and working fifty turns a minute—large marine engines.

170 x Q. Do you not know that in all of those engines, or most of them, the engineers have resorted to various contrivances in order to make the motion of the slide valve in opening slower?

A. I do not know that they have resorted to particular devices for that purpose. I know this fact, that the valves do not open with great rapidity in those larger engines, and it is also the same in all large engines with puppet valves where the puppet valves have not been made to open with great rapidity for fear of imposing too great and violent a strain upon the machine.

171 x Q. Do you not know that upon those engines various plans have been resorted to to level the ends of the slides so as to admit steam in the corner?

A. I do not know that anything of that kind has been put into practical use; I have seen descriptions of such things, but have never known them put into practical use on large engines.

172 x Q. Have you ever examined any of these large engines?

A. I have seen the drawings of a great number, but I have never seen the valves of any opened but one, which was the *General*
155 *Admiral*, and she was built in New York?

173 x Q. Have you not seen in the books that pointed incisions are made in the ends of the valves?

A. I do not recollect seeing pointed incisions made in the ends of the valves, but I have seen it described in the books that the ends of the valves were slightly skewed.

174 x Q. What was the object of that?

A. In order to admit steam more slowly to act upon the piston.

175 x Q. Was not that the only object?

A. Not necessarily; there may have been some other objects.

176 x Q. What advantage could be gained by cutting the ends of the valves so that they were skewed?

A. When working the valves by hand, and you want only to admit a small amount of steam at a time, you can admit a smaller amount of steam than if you opened the whole port.

177 x Q. You suppose, then, it was the purpose to work by hand?

A. Those were purposes that might be advantageous. I do not know the purpose without knowing the man that made it. In large engines, as I stated before, I know that that is done; in large engines puppet valves *vary*, as also do slide valves.

178 x Q. In large engines are not contrivances made for the purpose of reducing the lift of the valve so as to make it move slowly?

A. I know that there are contrivances made where, in lifting, the valve is made to move more slowly, but I never knew of such a thing being made in the ordinary manufacturing engines, and I never saw it described.

179 x Q. Do you not know of a contrivance called "Barber's check ring?"

A. Yes; I know there was such a contrivance, but I do not recollect the object of it.

180 x Q. The object of it is to make the valve open more slowly.

A. I never saw it.

181 x Q. You say it is an advantage to let steam on suddenly?

156 A. If you want to get advantage in economy, I consider it an advantage to let it work quickly.

182 x Q. Where is steam admitted into an engine to begin with?

A. When the engine is upon its dead centre.

183 x Q Is it not a fact, in the working of an engine, that there is a lead given to the steam valve?

A. Not always.

184 x Q. Is it not generally the fact?

A. It is true with some engines, but not a general fact; some locomotive engines work with a great lead.

185 x Q. Do you know any that do not work with the lead?

A. Yes.

186 x Q. Did you ever measure them?

A. No.

187 x Q. Do you not know, as a scientific proposition in engineering, that if an engine had a lead it would work to the best advantage?

A. No; I never knew an author to lay down the fact that they

must have a lead. I have seen a great many work with the lead, and a great many not; it is not a universal rule.

188 x Q. In engines working with the lead if the valve is opened, and the whole weight put upon her, is it not the result that you have to lift that weight?

A. It would be the fact if the valve were opened suddenly at that moment; on the other hand, the lifting would be done, perhaps, wholly or in part by the momentum of the parts moving in that direction.

189 x Q. If the momentum of the parts was not taken up in making that resistance it would be spent in driving the load of the engine?

A. If it might be available to do something else it would be spent upon something else; when you bring the piston to rest the whole of that momentum would be lost.

190 x Q. Do you say it is better to put the boiler pressure on when it is at the centre, or give her time to get over the centre?

A. If you are using a large marine engine, where there is danger of breaking the parts, it is not advantageous in practice to put
157 the whole steam upon the piston at the time it is on the dead centre. That is so when there is any danger of breaking down; but, if you take a strong stationary engine, I should say that you would get the greatest economy if you have the pressure on the piston as soon as possible after it has reached that point, and begins to recede from it. If the piston had to operate against more pressure than was sufficient to overcome the momentum of the parts, whatever you put upon the engines afterwards would be disadvantageous.

191 x Q. As a practical fact, do they not put the lead upon the exhaust upon engines generally?

A. Almost universally.

192 x Q. The effect would be to shut the exhaust valve. If you open the lower exhaust valve before the piston gets to the other end you shut the other?

A. There is no necessity for doing such a thing.

193 x Q. Mr. Sickles has a patent for doing that. When the upper exhaust valve shuts, then steam is confined in there?

A. Yes.

194 x Q. And forms a cushion?

A. Yes.

195 x Q. Is not that for the purpose of preventing a slam upon the centre?

A. No. I understand the object of that cushion is to overcome the momentum of the parts of the engine. For instance, if you take a cylinder and you want to overcome the momentum, in order to prevent its injury, you can overcome it by cushioning, or by giving a sufficient amount of lead to let in some steam.

196 x Q. Does not a puppet valve open more readily than a slide valve, the area of the parts being the same?

A. Do I understand you to mean that you consider the area the circumference? I do not see why you might not have a slide valve

open just as fast as a puppet valve. I have seen a slide valve open as rapidly as a puppet valve; and, on the other hand, not so quick.

197 x Q. Did you ever know a puppet-valve engine where the puppet valve did not open as fast, at least, to admit steam as was proper for the efficient and best operation of the engine?

158 A. I have never seen puppet valves except upon very large engines, with one exception; and I know that in that it did not open as fast as it should. I was driving an engine in a rolling-mill, and I am satisfied that the valve did not open fast enough to get full pressure upon the engine.

198 x Q. Did you ever know that a slide valve would not open fast enough?

A. I do not know that I ever saw it.

199 x Q. Your valve was too small?

A. It was small.

200 x Q. I suppose a small puppet valve would not admit as much steam as a large one?

A. No.

201 x Q. If the valves are made in proper proportions, is there any choice between the use of a slide and a puppet valve, reference being had to capacity to open rapidly?

A. I think so.

202 x Q. Which one would open the fastest?

A. The slide valve would open faster, under equal circumstances. When you want to get the best effect, you should get pressure upon your piston as rapidly as possible.

203 x Q. Does it not create a great amount of friction upon the revolving shaft?

A. If the parts stood still. But that is not the fact in practice. As far as I know, with the weight of the fly wheel resting upon the engine shaft, as is the case with ordinary manufacturing engines, the admission of the steam rapidly does not produce a practically great increase of friction.

204 x Q. Do you mean to say that in marine engines there is any loss of power by reason that the valves are opened slowly, and made to open slowly by contrivances for that purpose?

A. I have no doubt that there is, and that you could get a greater amount of power out of the steam. But, on the other hand, if you do so with a large engine there is a risk of breaking.

205 x Q. If there were any loss of power by reason of this slow motion it would be shown upon the indicator card?

159 A. If the loss be appreciable the indicator card would show it.

206 x Q. If the valve is opened slowly is there a loss of power?

A. Certainly.

207 x Q. Is there any loss of power by reason of the slow motion on that engine? [Handing to the witness several indicator cards which had been attached to marine engines. Witness examined them, and responded that he could observe no appreciable loss.]

208 x Q. Do you suppose that *that* valve was made to go slowly?

A. Not in proportion to the speed of this engine. If that engine had been a very fast worker, you might not have worked the valve rapidly enough. If you take a large engine that runs ten revolutions a minute, you might travel a large number of feet with the piston; but if you took a smaller engine, you might have to work fifty a minute. *Those* are most excellent cards.

209 x Q. Have you seen Corliss's engine cards?

A. I think I have, but I do not recollect when.

210 x Q. They were produced upon a former trial, were they not?

A. Not in any of these cases, that I recollect.

211 x Q. Did you ever get any as good as *that?*

A. I cannot recollect without comparing them.

212 x Q. What effect, if any, does the sudden putting of steam upon the piston have upon uniformity of motion?

A. If the engine has fly wheel enough it does not affect it at all, but in a big marine engine which has no fly wheel it would give a sudden start to the paddle wheel.

213 x Q. Now, sir, is there anything in this arrangement of Mr. Corliss's which makes this rapid opening a peculiarity of his invention in any way?

A. If you abstract the slide valve from his combination, and consider it as a distinct and separate thing, I do not know that there is any; but I never, before his invention, knew of a slide valve in combination with liberating valve gear.

214 x Q. Does the rapid motion depend upon the fact that it is going to be liberated?

A. No.

160 215 x Q. Has it any connection with the subsequent operation on the valve? Has the rapid movement of the valve in opening (which his patent says is an advantage) anything whatever to do with the peculiarity of liberating the valve gear? Does not the valve gear open the valve in the same form that it would do if it were not liberated?

A. He opens it by means of the liberating valve gear, while previously, so far as I know, they were not opened by this means.

216 x Q. He opens it by an eccentric?

A. Yes.

217 x Q. I ask you whether the liberating of the valve has anything to do with the peculiar manner which you say it held it; does the rapidity of opening this valve depend upon the fact that you are going to cut it off after opening it?

A. I do not know that it does. You are enabled to have the advantage of a slide valve, whatever it may be with the liberating valve gear. I understand the invention to be the combination of liberating valve gear with valves that move parallel with their ports. The slide valve might be made not to overlap.

218 x Q. Would that apply to puppet valves?

A. Not to puppet valves, but to a previous modification of slide valves.

219 x Q. Would this patent for this combination apply to a puppet valve which has what is called a check ring upon it?

A. No, as I understand it, it would not; but *that* valve *there* [model No. 5] is not a valve which overlaps its port after the valve is closed; the very instant the port is closed the valve is at rest.

220 x Q. We have got *here* [illustrating] a cylindrical bottom to the puppet valve and that fits in *here?*

A. I think that if *that* [the cylinder] were fitted absolutely tight, so that the steam was shut off when *that* cylinder meets that point, and that the valve could go on and continue its motion afterwards, I think that that would be substantially the same thing, *that* is, the puppet valve with the tight check ring, but *that* I never saw or heard of. I consider that *that* is substantially a slide valve. I do
161 not understand *that* to be an ordinary puppet valve; it is a puppet valve with a slide valve attached to it.

221 x Q. Does it make any difference in that organization, whatever Mr. Corliss' combination is, what kind of an instrument he uses, for the purpose of governing or controlling the time when the trip cut off shall shut?

A. As I understand it, so long as it be an instrument which is capable of attachment to the governor.

222 x Q. I speak of the governor now alone. Does it make any difference what kind of a tool that is which does cause the stop to vary its position?

A. As I understand it, not.

223 x Q. A machine, in which, by reason of the increased speed of the engine, a stop, ordinarily like Sickels' cut-off, made to come up and go down, is made to cut off shorter than before, and so it varies its position according to the speed: is that within that patent?

A. I wish you would show it to me.

224 x Q. [Handing No. 6 to witness.] Is that within Corliss' invention?

A. I think it is, sir.

225 x Q. There is a machine with the cam stationary; in this same machine, if you apply any arrangement which, when the engine runs fast, will draw those stops out sooner, and when it runs slowly will draw them out later in the action of the engine, is that machine within your comprehension of this invention?

A. Not necessarily; because it may so happen that the combination of the parts may be such that the set of the variable instrument is not determined by the governor, but by the power of the engine, and that the governor might be made to set that mechanism at work. In other words there may be no such combination between the parts that the movement of the governor produces an equal change in the position of the stop. In other words, in order to be with Corliss' invention it must be such a combination that every position of the stop corresponds with a certain defined position of the governor; there must be an intimate connection between the two; the position
162 must be under the entire regulation of the governor. I can imagine a case where that might not be the fact, and yet this might change when a change of velocity took place in the engine.

226 x. The court: You do not know but that the power of the engine might be used as a substitute for the governor?

A. Yes, sir.

227 x. Mr. Dikerson: You mean to say that if you used what is called a "mill governor," in which the fly-balls themselves do not move the stop, because they control and put something else in motion, that that is not within the case?

A. I do not think it is; what you call the governor and I do is not the same thing.

228 x Q. As I understand you to say, it is this: that when the fly-balls operate directly upon the stop in Sickles' cut-off, you then consider it is the machine of Corliss?

A. So far as I can understand it, it is.

229 x Q. But, if the fly-ball governor was used to set in action another mechanism, as, for instance, the power of the engine, and that power goes to work and move the stop, it is not within the patent of Corliss?

A. It is not.

230 x. The court: State the latter alternative of the proposition again; you say that when the power of the governor is used directly to regulate the stop—

Witness: To regulate the position of the stop, the change in the position is made by the governor.

231 x Q. You say that the arrangement is Corliss'?

A. So I understand it.

232 x Q. What do you say is not?

A. If this variable instrument is moved, or the position of it changed to vary the period at which liberation takes place, by the power of the engine, and the governor was merely used to start that power of the engine into operation, and the governor does not by its position
163 indicate the amount of change, I think then it would not be within Mr. Corliss' invention.

233 x Q. By the expression, "and the governor does not by its position indicate the amount of change," you mean to say what is called by me a "mill governor?"

A. I understand it to be not different from any other fly-ball governor. I think if you use such a screw apparatus to move that stop so that the governor's balls do not indicate the amount of movement it would not be within his invention.

234 x Q. In the mill governor, in which the balls are brought only into action, so that the power of the water will produce the change, you do not think it would be within his invention?

A. No.

235 x Q. Supposing the governor to set in action another engine, which other engine operates the change in the stop, is that within the invention or not?

A. I do not think that it would if I understand your proposition.

236 x Q. Supposing the mill governor were put on with a gearing under those circumstances do you think it would not be within Mr. *Corliss'* invention?

A. Yes, as far as I know the mill governor.

237 x Q. A double bevelled gearing in which the governor lifts one part and the governor's balls do not indicate the amount of the change, suppose that was used?

A. I do not think that would be within his invention.

238 x Q. Then, Mr. Renwick, the *A* machine, which is substantially a copy of the drawings, leaving out all THIS arrangement?

A. Yes, that shows the arrangement. If you take the upper one, *that* [pointing] is the cam operating with *this* link *here*, and the governor; that would show the first modification described fully in the patent; the governor moving that cam up and down.

239 x Q. Then that engine of Mr. Corliss has got first, a governor, secondly, a cam, which is rotated by the engine, and which knocks out a latch that connects the two parts of the valve together?

A. It makes it move laterally.

164 240 x Q. It disconnects?

A. Yes.

241 x Q. During that operation the governor is at liberty at all times to move that stop, except at the instant when it is striking out the connection.

A. Yes.

242 x Q. That, I believe, is claimed as the great merit of this invention?

A. Not that it is at all times free. The point is that there is a time in the operation of the engine when the governor is free.

243 x Q. Is there any of the different plans of the regulator and cut-off in which the regulator is not free at some time during the action of the engine?

A. That is the case (No. 5) where the governor is acting upon a valve in place of the throttle valve. When the other parts are not in contact, the governor then would be hampered by that arrangement—that apparatus.

244 x Q. *That* is common to *that* machine, and *that* one in this respect?

A. Yes; but there is this difference; *that* has nothing to do with liberating the steam valve.

345 x Q. Suppose you put in Corliss's a distributing valve under the cut-off steam valve?

A. That would be substantially the same thing. It would be one of those colorable changes made, as I call them, for the purpose of evading the patent.

246 x Q. Does Corliss make any allusion whatever to this peculiarity, that the valve is in a particular place?

A. No; but his whole patent shows that this is a contrivance which operates the steam valves of the engine—that is, the liberating valve gear.

247 x Q. I see he has got a description of model 5. Does he make any such discrimination as that against it in that description? [Handing patent to witness.]

A. [Reading from patent No. 763, page 2, line 88.] "We learn

from standard works on the steam-engine that it has long been well known that great advantages in the economy of fuel would accrue from a change in the application of the regulator of steam-
165 engines from the *throttle* valve to the expansion or cut-off valves. And yet, until the date of my invention, the application of the regulator to the throttle valve was practically the universal rule in working engines in all parts of the world, if we except a few doubtful instances of isolated engines of very limited capacity—those constructed with a liberating valve gear forming no exception to that rule.

"One of the exceptions above referred to is described in 'Tredgold's Treatise on the Steam-Engine,' at page 283, article 492, and in the explanations of plate XVI of that work, in which plate the engine is exhibited by drawings. Here the regulator is represented as applied to a rotating cam, upon which a puppet or lifting valve was raised, and, being held up the required length of time, was lowered to its seat. As this cam was designed to govern, by its extended form, the periods of opening and closing the valves, it was elongated so as to admit within its length all the gradations of form requisite for closing the valve at earlier and later periods of the stroke of the piston, and then it was placed upon an axle in bearings, which admitted of its endwise movement to the extent which was necessary for bringing, as required, the several gradations of form throughout its length, corresponding to the varying period of closing, within the plane of movement of the valve lever. The range of motion of the regulator was then adapted to the length of movement required by the length of the cam. This device is represented as applied, 'by way of experiment,' to what is termed a 'portable engine,' and the valve operated by it is shown in the drawings side by side with the *throttle* valve."

248 x Q. I ask whether Mr. Corliss attempts to discriminate in his patent between the cut-off put outside the distributing valve and the main valve?

A. I understand there is a discrimination in this respect. The whole tenor of the patent describes a liberating valve gear applied to steam valves, and none other. He describes his liberating valve gear operating upon two valves at the two ends of the cylinder, which are independent of each other.

166 249 x Q. Now the liberating valve gear, such as Corliss's, being in existence when he put the cut-off to it, do you mean to say that there is a substantial distinction between using that cut-off in combination with the governor *there* and using that cut-off in combination with the governor *here*, [pointing to the two machines,] when that governor was known from the time that it was made, and this cut-off came into use between that time?

A. Certainly there was.

250 x Q. Please state wherein the invention consists—*this* valve gear being in use (No. 5) without a governor, the governor being applied to the other forms of cut-off that were in use. Explain what

it was that Corliss did that constituted an invention to apply the governor to that cut-off in place of applying it to the other cut-off.

A. He made a new combination of a governor with a liberating valve gear when before there never existed such a combination.

251 x Q. Did there exist liberating valve gear before this Sickles's cut-off came into use?

A. Not that I know of.

252 x Q. When Mr. Sickles brought his cut-off into use, then Mr. Corliss applies his governor to it. Suppose that case?

A. I say that in the first place Sickles's stop was adjustable, but he had arranged to fix it in position. Now the first thing Corliss had to do was to throw away that arrangement, make a movable stop to be shifted to and fro from one spot, not tight or fast, and then he connected his governor with that stop. He was the first one who really devised practical means of applying the governor to the liberating valve gear. He made the first combination of the governor with the liberating valve gear, so as to obtain the mode of operation which he has described. He combined the two together. He took out the set screw and applied the governor. That is the mechanical work that he did.

253 x Q. In Corliss's engine the governor moves the stop that drives out the valve?

A. It sets the cam in position so as to determine the period when separation takes place.

167 254 x Q. In the Green engine does not the detachment take place by reason of the depth of the engagement?

A. Immediately it does; but that depth of engagement depends upon the set imparted to the gauge bar by the governor.

255 x Q. In the case of Green's is not the governor loaded down by the stop or tappet that opens the valve, so that the governor cannot move during the time that the valve is being opened?

A. There is no doubt but that the governor is hampered, so that if it did move, it would not move as sensitively as it should.

256 x Q. Did you not experiment and find that the governor could not detach it?

A. No, I did not. My experiments satisfied me that the governor could detach it.

257 x Q. On Mr. Green's machine the regulator is hampered during the time of the opening of the valve?

A. Yes; but not hampered by the strain of opening, but by the friction of the parts against the bar.

258 x Q. If you take out the stop, the revolving cam of the Corliss engine, it will not detach?

A. No; I believe this is not made so that it will detach?

259 x Q. If you take out this bar in Green's, the engine will not work unless it should detach?

A. That depends on how the eccentric is set. If the eccentric is so set as to lower the valve back upon its seat, it will. I have not seen an engine with its eccentric set as in the drawing. The drawing shows an engine that will not work; that will not admit steam to

act upon the piston as that drawing is shown. The steam would not act upon the piston until it had completed a quarter of its stroke.

260 x Q. Have you seen the engine in use?

A. Yes, sir.

261 x Q. Do not those in use begin to open the valve at the beginning of the stroke?

A. Yes.

262 x Q. Do they not hold it open during the stroke?

A. They would hold it open until about $\frac{5}{8}$ stroke.

263 x Q. That engine would not work if there was no disconnection?

168 A. No; because the valve would not be lowered over its port.

264 x Q. Therefore that engine must trip independent of any connection with the governor at all?

A. As matter of fact the one I saw running did so.

265 x Q. If in Corliss' machine you take away the stop or cam, the engines will not go on?

A. It will then be a full-stroke engine; there would be no regulation in either the defendant's or the plaintiff's.

266 x Q. Yet you say *that* valve gear is the same arrangement as *that?*

A. I say that *this* is a detachable valve gear, and *that* is detachable valve gear, and the combination of the governor with the detachable valve gear in the defendant's is the same as in the plaintiff's.

267 x Q. Do you make any distinction between liberating valve gear and detachable valve gear?

A. No.

268 x Q. The rocking arm is not new?

A. The rocking arm of itself is not new.

269 x Q. Or the connecting rod of itself with the hook upon it?

A. No; but I never saw the rocking arm and the connecting rod together until I did so in Mr. Corliss' engine.

270 x Q. The first claim in his patent 780 is "combining with the rocking levers and their equivalents for opening the valves, the shoulders on the spring bars, or their equivalents, substantially as described, and for the purpose specified?"

A. Yes.

271 x Q. At folio 20 he says: "This part of my invention consists in combining with the levers that operate the valves the shoulders on the spring bars, the said shoulders being borne towards the axis of the levers by the force of gravity or springs." That part of the description has no connection with the tripping arrangement, has it?

A. There is no statement there that any other thing than those two parts are put in connection. The other part of the invention is

169 to a combination of these with a peculiar kind of stop. I understand that if this combination were used with a cam you might have a different combination from the second.

272 x Q. I want to know whether the stop is included in that combination?

A. I do not understand that it is involved.

273 x Q. Then it is merely the rocking shaft and the arm and the shoulder on the slide bar?

A. Yes.

274 x Q. The rock shaft is old?

A. Yes, of itself.

275 x Q. You have said, as I understand you, that this is the same combination, whether it goes full stroke or trips?

A. As far as I understand it.

276 x Q. Take this eccentric hook; there is a rocking lever to work with?

A. Yes. This rocking arm is not like the one described in the patent. This terminates in a pin, but the one in the patent terminates in a square face against which the shoulders of the eccentric rod act. The difference is that by reason of that you can get a different operation.

277 x Q. You have said that this was a claim of two simple things, namely: a rock lever and an arm that has got a shoulder on?

A. Yes; and from the different construction of the parts you have the capacity of obtaining a different mode of operation.

278 x Q. Do you think, then, that the shape of the shoulders in any way determines this question?

A. Yes.

279 x Q. But here is the ordinary eccentric hook which has got such a shape as that, and always works the valves.

A. Yes; if you take such a hook as that, and introduce it into Corliss' machine, in combination with such a rocking arm as he has described, you would have the same thing; you must take his rocking arm.

280 x Q. Would not this open the valve?

A. I suppose it might.

281 x Q. Would it not close it?

A. I suppose it might, but it is not capable of detachment at all.

170 282 x Q. Would a round pin put on the end of that arm, operating as a detaching pin, be within his patent?

A. As far as I understand it, I do not think it would be within his patent.

283 x Q. If we made round pins on the ends of these tappets, would that be within your invention?

A. That depends entirely on circumstances. It might or it might not.

284 x Q. Show us the part of the patent which describes the shape of the pin.

A. There is no part of it. It describes the rocking arm and the sliding rod in a particular way.

285 x Q. The operation is confined, you say, to the peculiarity of the square arm and this corner, whereas the old form of corners are round?

A. I never saw an old form operating to detach the valves. I

have never seen an arrangement of this kind that Mr. Corliss has described.

286 x Q. In Green's patent there is one bar going backward and forward as *there*, and that bar holds first one valve and then the other?

A. Yes.

287 x Q. Just as that bar holds first one valve and then the other?

A. Yes.

288 x Q. Then, upon Mr. Corliss' engine there are two bars, each one separate from the other, one opening one valve and the other the other?

A. Yes.

289 x Q. You think that that arrangement is more like Corliss' than that?

A. I do.

290 x Q. If you put the trip upon it and put the governor upon it it would infringe your patent?

A. I think it would of the regulating patent, if the governor was of the right kind, and the connection of the governor with the tripping apparatus. I do not think a connection between the mill governor and the other parts would.

291 x Q. Mr. Corliss says, "I do not wish to be understood as
171 limiting myself to the special construction and arrangement of the several parts, but to cover all merely formal variations." Is it a formal variation to make a hook round?

A. I think there would be when there is a tendency to slip off. It is more than a formal alteration.

292 x Q. Would it be of any practical consequence whatever in throwing that off the small part of the round point?

A. Yes; I think you would have a liberating valve gear, but which would not work so well in practice.

293 x Q. It would trip at the same time?

A. There would be a change. It might be made to trip at the same time.

294 x Q. As far as tripping at the same time you would have the same effect?

A. Yes.

295 x Q. Would the use of air in Sickles' dash pot be the same thing as Mr. Corliss has patented here?

A. I do not know.

296 x Q. You know what Sickles' dash pot is?

A. I think if it was an apparatus to use air, and combined with the valve gear, it would be substantially an air cushion. Whether air could be used in that or not I cannot tell.

297 x Q. Suppose it to work with air, would it be the same thing?

A. If it did work on air it would be. If it would work equally with Corliss' air cushion, and did, then it would be the same thing.

298 x Q. There is nothing in that, excepting, as I understand a description of this machine, it is a claim for using air in the place of some other fluid in a cup?

A. It is a claim for using air.

299 x Q. Would not water work as well?

A. Water would work differently.

Redirect.

300 Q. In your cross-examination you spoke of having had charge of a rolling-mill, working by a steam-engine. How was that engine operated?

172 A. By the hand of the engineer, applied to the throttle valve.

301 Q. Did you use the throttle valve?

A. Yes.

302 Q. Why was the hand of the engineer used?

A. In order to regulate the engine when we required changes in the power of the engine to do different kinds of work.

303 Q. Had you a governor applied to the throttle valve?

A. We had not.

HARVEY WATERS called and sworn:

Examined by Mr. Stoughton:

304 Q. Your profession, I believe, Mr. Waters, is that of a machinist?

A. Yes.

305 Q. And your employment has been for some years past—what?

A. I have been considerably engaged in testifying, in cases of this kind, before the United States circuit court.

306 Q. Have you examined the patent, specification, and drawings, which I will call No. 763, being a patent for the combination of the regulator for liberating valve gear, issued to Mr. Geo. H. Corliss?

A. Yes, sir; I have.

307 Q. Have you seen the machine embodying that mode of regulation in operation?

A. I have.

308 Q. Will you state, in such a way as you think will best enable the court to understand you, your views, in a general way, what that operation, as described, is, how it operates, and what it effects in its operation, alluding to the model as you please, for the purpose of illustration?

A. I understand this invention of Mr. Corliss to go to the regulation of the motion of the steam-engine by cutting off the steam at the steam valves earlier or later, according to the requirements of the work to be done, in contradistinction to the method of regulating by the throttle valve, allowing the steam to pass from the boilers

173 against the piston, and to pass as free as possible, and cut off at such portion of the stroke as will accomplish the work, either sooner or later in the stroke, and when cut off to cut off as quickly as possible, the point of cut off to be indicated by the direct action of the regulator. What I mean by the regulator is, the two balls hanging upon the arms, on which they are balanced in their position, the tendency to go inward being by gravity, they being hung inside, and the tendency outward being by the tangential force consequent upon

their revolution. Now, the position is taken in that angle in proportion to the speed. When there is a variation of the speed, there is a variation of the position of the parts, so that the cut off takes place according to that position. In the throttle-valve regulation the same regulator was used generally, and attached so as to work in the same manner, only, instead of being attached to the steam valve, it was attached to the throttle valve, making the orifice in the pipe greater or smaller. Mr. Corliss always gave the same open port and free pipe; the steam working with full pressure until it is cut off, and when it is cut off working by the expansive force at no expence of steam, because there is no throtting the steam from the boiler. I think that is the essential difference between Mr. Corliss's machine and what was in practical use before.

309 Q. What was that in practical use?

A. The best practical machine that I know of was the Tuft machine. That used the cut-off, cutting off at the same portion of the stroke, just according to the discretion of the operator, as he chose to set his eccentrics. They used two eccentrics—one to cut off, and the other to work the valves. In addition to that, for the purpose of regulation, they used the throttle valve, so that the regulation was always by the throttle valve.

310 Q. Will you state to the court what the operation is of regulating by the throttle valve upon the steam, or upon the pressure of the steam?

A. The operation is to reduce the pressure of the steam in the cylinder, by choking it through a small orifice, so that too much steam should not pass in, leaving the steam attenuated in the cylinder.

174 311 Q. If you work at full stroke, you can still regulate it by means of the throttle valve?

A. Yes; the steam passes through the throttle valve always, you always measure off the same volume of steam in the cylinder at every stroke, and your steam becomes lighter as you throttle it closer.

312 Q. What is the effect of that upon the expansive force that you would otherwise get in using steam at full pressure from the boiler?

A. It sustains a loss; the expansive force of the steam is important, because when that is used it costs nothing.

313 Q. Will you compare this mode of regulation with throttle valves with that introduced by Mr. Corliss, stating the advantage of the latter, if it has any?

A. The advantages are, that as long as you use steam at all with the Corliss machine, you use it at its full pressure; while in the throttle valve you always use it at less than its full pressure.

The court: We do not exactly get your idea as to the mode in which the throttle valves were regulated in the machine of Tuft, to which you have referred—the machinery by which they were regulated.

[Witness illustrated, on model, the action of the throttle valve.]

Examination resumed: You were going on to answer the question that I had put. Perhaps you had better now do so.

Witness: What I was going to say was this: That in this machine [Corliss's] the theory of it is to open and free the port, so as to use steam at full pressure upon this piston as long as it escapes from the boiler—letting it pass freely so as to have the same pressure on the piston as on the boiler. When the valve is closed the machine goes on working by the expansive force of the steam, no steam passing from the boiler into the cylinder, but merely by the expansion of the steam the power goes on. There can be no doubt that costs less. All the power that can be got in that way, without a loss somewhere else, is a clear gain.

175 314 Q. Does it cost more to make a cubic foot of steam at 100 lbs. pressure to the inch than four times that quantity at 25 lbs. pressure?

A. Just the same.

315 Q. Take steam at 100 lbs. pressure, and use it for the purpose of driving a piston through a cylinder four feet long, and state what would be the force of the one as compared with the force of the other—one at 100, and the other at 25?

A. Four times. Now, I suppose you work this piston 12 inches with the full pressure of the steam, and then cut off the passage from the boiler, the machine goes on working by the expansion alone for another 12 inches, and the steam in the cylinder will gradually have been reduced to a pressure of 50 lbs., and all the power exerted by the expansive force of the steam will be a clear gain, as there has been no passage of steam from the boiler.

316 Q. You have just illustrated the difference in gain between taking 100 lbs. of steam and 50 lbs., and using its expansive force by cutting off. Now, let us suppose that you have a boiler for steam of 100 lbs., and never permit it to go into the cylinder till you attenuate it by passing it through the throttle valve at a pressure of 50 lbs., do you lose any of your expansive force?

A. Certainly.

317 Q. How much?

A. I understand the loss is the same in proportion, whether you cut off or do not cut off. I understand if you work a cylinder four feet long, with a pressure of 50 lbs. to the inch, and another of two feet long, with a pressure of 100 lbs., and work them both with throttle valves, that there may not be much difference in the final result. But you have always a difficulty with throttle valves, more or less. You only modify it by using the cut-off.

318 Q. Then the only regulation by the throttle valve is effected by creating a difference between the pressure on the piston and in the boiler?

A. Yes.

319 Q. And that difference is in favor of that side towards the boiler?

A. Yes.

176 320 Q. Now, suppose you take a cut-off such as is used by Mr. Corliss by means of his variable cut-off at the steam-valve, taking the steam in at full pressure of the steam in the boiler, then you lose none, as I understand it, of the expansive force which you lose by the use of the throttle valve, as you have illustrated it. When you cut-off by regulating at the steam valve, opening the ports wide, I ask you if you get rid of that attenuation of the steam which is due to the throttle valve?

A. Substantially you do; but as some time is taken up in opening and closing the steam ports, you cannot quite come up to it.

321 Q. Will not any contraction of an aperture wire draw it more or less?

A. Yes.

322 Q. So that, practically, you will find it impossible to get exactly the same pressure into the cylinder through the ports that you have in the boiler?

A. When the steam is let on the piston moves slow, and the sudden opening of the ports is not of as great consequence: but as the piston goes, a more rapid and sudden closing becomes more important.

323 Q. I think you remarked that the best engine that you know of in use was the Tuft engine, working with throttle valves, and the cut-off with steam valves?

A. Yes; and it is used now, I believe, considerably. There was one at Springfield, and it is there now, I understand.

324 Q. Your attention was called off while you were stating generally the agencies by which that mode of regulation worked. Will you state by what agencies you understand the governor acts in effecting this liberation.

A. It acts by the change of position due to the two forces, consequent upon the regulator slide being connected directly to some instrument which is actuated by the power of the machine, and which goes to disengage the valve from its connection. It breaks that connection sooner or later in the stroke, according to the wants of the engine. The power of the governor being a balance of two forces, its available power is very small—very delicate. It was a

177 matter of much difficulty to get such an arrangement of parts as to allow the connection being made, direct as it was, in the throttle valves connecting this instrument, which was to break the attachment in that delicate manner, so as to have power sufficient to do the work when the machine was pretty heavy, and the apparatus necessary to move the valves required necessarily considerable strength of material. Mr. Corliss, in his first patent, accomplished it by the use of the helical cam on the sleeve of the governor, attaching the governor to that sleeve, and by carrying it up or down, the cam was thrown in a different position, so that the connection between the two parts of the valve gear was broken sooner or later.

325 Q. Describe Mr. Corliss' machine and the defendant's.

A. The difference is simply this, as I understand it: *here* (defendant's) are two catches upon one bar, and *here* two catches in Corliss'. These catches take hold of the valves and open them by the power

of the machine, and bear the same relation to the machine that they do in Corliss'. The point of time at which this disengagement takes place is consequent upon the position of these balls. The precise mechanism is different. Here (defendant's) is a tappet upon *this* bar working up and down, and taking more or less hold, according to the position of the balls. The deeper they hold, the later the detachment, and *vice versa*. In Corliss', as described in the first patent, instead of working out by this change of lines, it is worked out by the cam. Here the amount at which this should take hold here is governed by the regulator. So that the cut-off is dependent upon these balls in the same way as in the other.

326 Q. How do you regard them, substantially the same or substantially different?

A. I think they are substantially the same.

327 Q. I will call your attention very briefly to the other patents, and I will take No. 780, which is a patent for the modification of the valve gear, which is shown upon model *C*.

A. I know what it is.

328 Q. You have seen machines embodying that form of valve gear in operation?

178 A. I have.

329 Q. State briefly to the court what that modification is, and then state whether you find it in use in the defendant's model.

A. *That* (Corliss') is a cylinder set upright, and the catch pieces are attached to the wrist plate, so that they take hold of the rocking arm, and the regulator is connected with a gauge bar or stop underneath these levers, and the regulator moves them out *here* in accordance with the speed of the engine, and thus disengagement takes place as they are moved sooner or later.

330 Q. I speak more particularly of the rocking levers.

A. I understand that patent relating particularly to the use of *that* catch with the rocking lever.

331 Q. Now, looking at it in that way, and viewing it as a modification of valve gear, do you find that in the defendant's or not?

A. That is in the defendant's. I look at it in this way: I think that is a sub-arrangement for regulation, containing the same thing as the original patent. It is one of the modifications of the valve gear, containing the same mode of regulation as the other.

332 Q. You find that modification of valve gear in the defendant's?

A. Yes; only this lower face always moves in a right line when it is in connection with a rocking lever, I believe, and that moves in a curved line; but they both disengage by the movement, and departing from each other.

333 Q. Taking the patent combining the liberating of the valve gear with the slide valves that overlap their ports, do you find the same invention in the defendant's machine?

A. Yes.

334 Q. Having said that you find the liberating valve gear in the defendant's, and it being admitted that they are governed in their

closing by an air-cushion, it is hardly necessary to ask you if you find that in the defendant's machine?

A. There cannot be any doubt that it is there.

179 *Cross-examination by Mr. Dickerson.*

335 x Q. Have you ever had any practical acquaintance with steam engineering?

A. No.

336 x Q. All that you know about it is what you have obtained from books, or otherwise?

A. Yes; I do not consider myself well read up upon the subject. There are certainly some points about it that I think I understand in regard to this machinery. I think I understand this mechanism about as well as any one.

337 x Q. I have heard you upon this subject before. You said just now that it would cost as much, and no more, to make high steam than low steam. Where do you find out that proposition?

A. It is an admitted proposition. It is something like the multiplication table.

338 x Q. Have you ever studied Reignault's experiments made on behalf of the French government several years ago, where the whole question is settled?

A. No.

339 x Q. There was a time, sixty years ago, when it was supposed so. An engine being set at a particular point of cut off, say at a quarter stroke, does it make any difference in the economy with which the fuel is used to drive that engine whether the steam be admitted at one pressure or another?

A. I think not, provided you always use the same amount of power upon it, and do not regulate it at all.

340 x Q. Take the throttle valve; we have got steam generated at one hundred pounds in the boiler, and an engine cutting off at one quarter stroke; we can let steam into it at one hundred pounds nearly, and it will go a quarter of the stroke, and be there cut off, and expand down to the twenty-five pounds at the end; or, by using the throttle valve, throttle down the steam, so that it comes in only at fifty pounds; in the first place you get steam in at one hundred pounds, and in the second place at fifty pounds; it will get in steam at half the power, and use only half the steam; then there is no loss in that by using the throttle valve in that case?

180 A. No, perhaps not.

341 x Q. It is theorically, I suppose, undoubtedly true that if you have a perfect engine to work in you gain by carrying expansion; every increase of the ratio of expansion is a gain?

A. I do not think there is any doubt about it.

342 x Q. Then in practice it is easy to carry expansion beyond the point of economy?

A. Like every other good thing you can run it into the ground.

343 x Q. Did you hear the examination of Mr. Renwick as to the

advantages and disadvantages arising from the throttle valve and cut-off?

A. No.

344 x Q. You said that the problem in this case that Mr. Corliss had to solve was to get a regulation in which the apparatus to be operated upon by the governor was sensitive, so that it would be readily affected by the governor.

A. I said it was part of the problem.

345 x Q. The result of having a machine extremely sensitive is the most important distinction between these, is it not?

A. I said that Mr. Corliss was the first to use that kind of connection successfully.

346 x Q. I am talking now of the difference between the machines when it was so produced, and what produced it.

A. Show me the machine you refer to.

347 x Q. I will take No. 5—Tredgold; I refer to the patent 763, at fol. 95.

A. This machine (No. 5) is an attempt to regulate by the cut-off, instead of by the throttle valve, having the cut-off at the same place as the throttle valve, substantially; and besides, it is so connected that although the valve closes with the weight, it is always under the control of the machine, that is, it is held up by the machine, and it rides down upon the machine, and being held up by the sleeve of the regulator, it has a tendency to embarrass the regulator in its action. Another great fault is, that it is not connected with the steam valve; it is only connected with one valve; it should be connected with both valves, and they should be, as near as possible, at the end of the cylinder, of course. I do not think it is so good a machine as
181 Tuft's, especially when the machines come to be of considerable size.

348 x Q. That method of regulating by the cut-off is in common use now at the back of the slide valve?

A. I do not know of any.

349 x Q. One distinction that you make here is, that in Corliss' machine the governor has to move the thing which has not any load upon it, except the very trifling work of knocking out the catch at the proper time?

A. Yes.

350 x Q. Whereas the governor of *this* (No. 5) has a load upon it which embarrasses it in its action to lift the valve?

A. Yes.

351 x Q. And one other distinction is, that the cut-off valve *here* is not put at each end of the cylinder, and distributes by an inferior valve?

A. Yes, and still another; this is not a trip valve.

352 x Q. Does not the valve of *that* machine (No. 5) drop by gravity, without resistance, and leave the edge of the cam?

A. No, it cannot do that; it comes down pretty quick.

353 x Q. Is not that valve liberated from the lifting motion, and permitted to go down by gravity, or a spring?

A That would depend on the make of the machine.

354 x Q. Is Mr. Corliss the inventor of putting the cut-off at each end of the cylinder?

A. No.

355 x Q. Mr. Corliss applies the governor to the cut-off which was put at each end of the machine by somebody else?

A. Mr. Corliss was not the first to make detachable valves.

356 x Q. Your objection to this (5) is, that the cut-off is here placed in the middle and not at both ends You say that Corliss' has a cut-off at each end; is that any part of Corliss'—his putting the cut-off at each end?

A. I like to take a thing as it is. I do not know how he got those things together.

357 x Q. Is Mr. Corliss the inventor of putting the cut-off at each end of the cylinder?

A. No, sir.

182 358 x Q. Then he applies the governor to the cut-off which he did not put at each end of the cylinder?

A. That is another thing.

359 x Q. Do you know of any fact which shows that he does not?

A. No.

360 x Q. You say that in that consists one of the merits of this arrangement. Is merit due to a man for that?

A. I think the merit is in the idea of regulating in this way, and putting the machine in a condition to do it.

361 x Q. *Here* is the engine with this adjustable cut-off at each end of the cylinder, and Mr. Corliss puts the cut-off by cutting off at each end, instead of putting it at the middle of the cylinder?

A. He has to put it at two places. He conceived the importance of bringing it there. That is what he did.

362 x Q. You say that the merit of his invention is, that the cut-off is at two ends of the cylinder instead of being in the middle. Was that Mr. Corliss' merit, or the man's who put the cut-off at the two ends?

A. I was not speaking of the merit of Mr. Corliss, but of his machine.

363 x Q. You say that Mr. Corliss has made some variations in the Sickles cut-off, in altering his governor to his, and that that makes a peculiar case of it?

A. I think he has taken the proper course.

364 x Q. You assume that Mr. Sickles' cut-off was invented only for puppet valves?

A. No, I do not; but I never saw it in any other shape.

365 x Q. Is it an invention for puppet valves, or any kind of valves?

A. It may be used for other kinds.

366 x Q. Have you ever seen those puppet valves working with that governor?

A. Yes, sir; and working badly.

367 x Q. What do you mean?

A. They did not work well.

368 x Q. Where did you see such a machine?

A. At Goram's, in Providence.

369 x Q. That had a pitcher governor on?

A. Yes.

183 370 x Q. Do you not know that there are a great many of Sickles' cut-offs which work with the fly-ball governor on?

A. No, I do not.

371 x Q. You were a witness in the action of Sickles *vs.* Corliss, I believe?

A. Yes.

372 x Q. I ask whether on that occasion you did not testify that the principal distinction between this machine and Mr. Corliss', and those that preceded it—the French cam-machine and others—was that in his machine the stop was sensitive so that the governor could work it, and in the others tied down fast by the load upon the governor?

A. I really do not remember what I did say. I have no recollection of saying anything.

373 x Q. Did you not testify, and use that as the distinguishing features between that machine and those that preceded it, that that was sensitive, because the stop had no work to do, and that in the French and others, the governor was rendered sluggish because it had to do the work of moving the valve?

A. I might have said something like that; but it would be true.

374 x Q. Was it not the point on which the patent was put by you?

A. I cannot say.

375 x Q. Was any distinction taken by you between that and the old ones?

A. I am sure I cannot say.

376 x Q. On that machine of Mr. Green's is not the governor tied up, and hampered by the load of lifting the valve?

A. Yes.

377 x Q. It is not so in Corliss'.

A. I believe not.

378 x Q. It is in Green's, and in No. 5?

A. It is not so bad as in No. 5; *this* is under pressure longer than the other.

379 x Q. During the whole time that valve is open?

A. Yes.

380 x Q. And so it is in the machine of the defendant?

184 A. Yes; but this is intended to have the valve open longer.

381 x Q. During full stroke, or any portion of the stroke?

A. It may run half stroke.

382 x Q. Does it not run more than that?

A. I think not. *This* machine regulator is fastened in one direction, and that may move in another.

383 x Q. The regulator may move, but it produces no effect?

A. It produces no effect until the next stroke.

384 x Q. Did you ever know of any trial being made upon Cor-

liss' arrangement, to determine what was the advantage of using it by the the cut-off regulator by the governor?

A. No.

385 x Q. You have been a witness in four lawsuits in this case?

A. Yes, sir.

386 x Q. And have tried several experiments, have you not?

A. I never tried one in my life.

387 x Q. I suppose you have been present when they were tried?

A. I was present at Newport, where they undertook to show the variations by throwing off a large amount of the machinery.

WILLIAM STEARNS called and sworn.

Examined by Mr. Stoughton:

388 Q. Where do you reside, and what is your present employment?

A. I reside in Portsmouth, New Hampshire. I have charge of a cotton establishment there.

389 Q. Is it a large business?

A. Yes, sir.

390 Q. How many spindles?

A. 32,000.

391 Q. What is your motive power there; what engines do you use now; and how long have you used them?

A. We have used Mr. Corliss' engine four years.

185 392 Q. With this method of regulating the governor and cutting off the steam valve?

A. Yes; a vertical engine.

393 Q. At the time that engine was introduced into your establishment, what engine were you using, and how long had you been using it?

A. We were using Tuft's engine, double cylinder, 24-inch diameter and four feet stroke.

394 Q. High pressure?

A. High pressure.

395 Q. About how many pounds steam did you ordinarily work upon it?

A. About 80 to 85.

396 Q. How many boilers did you use, and of what description?

A. We used eight boilers, of four feet diameter and thirty feet long.

397 Q. How many spindles did you operate with Tuft's engine?

A. About 27,000.

398 Q. How was that engine regulated, if at all; what mode of regulation was used?

A. It was regulated by the common governor at that time attached to the throttle valve.

399 Q. Did you use the cut-off?

A. We did, sir.

400 Q. To cut off at the steam valve?

A. The steam valve cut-off near the ports.

401 Q. What kind of an engine was that, as regards excellence, for that kind of an engine?

A. It was considered one of the best at that time, sir. It was an engine that Mr. Tufts took a great deal of pride in. It was considered one of the best at that time, sir—his "pet engine," he frequently called it.

402 Q. At the time it was taken out, was it in good condition?

A. Yes, sir.

403 Q. Now, sir, in using that engine, how short did you find it practicable to cut off the steam, using the throttle valve as a regulator?

A. About one-third.

186 404 Q. Did you try to use it with a short cut-off?

A. We did.

405 Q. What was the result?

A. The result was that we could not get steam enough to run it.

406 Q. For the maximum of work it would not do?

A. It would not do, sir.

407 Q. Now, you say that you have been using Corliss' engine four years?

A. Yes.

408 Q. Now, what were the dimensions of the cylinder of the Corliss engine?

A. Six feet stroke and twenty-three inches diameter.

409 Q. More than one cylinder?

A. One cylinder only.

410 Q. High pressure?

A. High pressure.

411 Q. About what pressure did you run it?

A. About 80 lbs.

412 Q. Give the velocity as the ordinary run of the old to the new engine.

A. The velocity of the old engine was about 32½ revolutions in a minute; that of the new about 39½.

413. The court: That is, you mean Tuft's?

A. Tuft's was 32½.

414 Q. And Corliss' 39½?

A. Yes.

Mr. Stoughton:

415 Q. Now, with the Corliss engine, did you run the factory at a greater or less speed than before?

A. We for three years ran it at the same speed, but now run it at a greater speed.

416 Q. And when you run it at the same speed, at what velocity did you run the new engine to get the same velocity as the old?

A. 37½ revolutions.

417 Q. Now, you have given us the diameter of the cylinder of

the new engine; did you use the same boilers, or any portion of them, that you used with the old?

187 A. We are using the same boilers, as far as we do use them.

418 Q. How far did you use them?

A. We are now using four boilers instead of eight.

419 Q. Has that been the number that you have used ever since you commenced using it?

A. Yes; excepting occasionally, when we put on six.

420 Q. How long did you make use of this experiment?

A. Two weeks, during four years.

421 Q. Now, sir, what number of tons of coal did you use per annum—did you consume with your old engine, doing the work of 27,000 spindles?

A. Nearly 1,800 tons.

422 Q. And you now operate 32,000 spindles?

A. Yes.

423 Q. And what number of tons per annum did you use with the Corliss engine?

A. We are using at the rate of less than a thousand at the present time?

424 Q. How many thousand spindles did you drive with it?

A. 32,000.

425 Q. Now, sir, is the work done with each of those spindles, considered separately, less or greater than the old spindles?

A. Greater than the old spindles. We have increased the speed of the spindles and work, making grosser articles. We have increased the speed of the engine from 37½ to 39½. All the machinery is increased in proportion. In the next place we are making heavier articles, as 12 to 14.

426 Q. Now, you have given us the work done and the saving effected, what is the comparative, or what has been the comparative regulation of the two, as you observed them, as to uniformity of speed?

A. The speed has very much improved; and as to uniformity, the new engine is more perfect than the old one was.

427 Q. Does that greater regularity in the action of the machinery enable you to run your spindles faster?

A. It enables us to run with more uniform speed, and ena-

188 bles us to make more perfect work, especially in our weaving.

428 Q. Can you give any idea of the saving effected by reason of the more perfect work—the percentage of the saving on the work you do?

A. I have no data, but I know the product has increased.

429. The court: Do you speak in relation to the stock?

A. No, sir; I speak of the quantity of work produced.

430 Q. In proportion to the number of spindles used?

A. We have increased the speed of our spindles, and throw off more work. We urge up everything as much as possible. With the old engines we frequently lacked full speed. If our fires were down, our speed was down. We have no trouble of that kind now.

431 Q. Was there any arrangement between you and Mr. Corliss as to the mode of payment of this engine for saving fuel?

A. Yes.

432 Q. What was it?

A. He was to put in an engine for the saving of the coal for three years, over that used by the old engine.

433 Q. What did the saving amount to in three years?

A. We paid him $12,000 and a little over. The saving was a little over 800 tons a year.

Cross-examined by Mr. Dickerson.

434 x Q. Do you know what kind of valve gear and cut-off was run in the old engine?

A. It was the usual cut-off that Tuffts used at the time, one valve operated for both ends of the cylinder.

435 x Q. Was it one slide valve on top of another?

A. No; there was space between them.

436 x Q. Were there separate exhaust valves on that engine?

A. There were not.

437 x Q. Was there not a cut-off valve in the middle of the engine that distributed steam to one side and the other?

189 A. Yes.

438 x Q. Look at *that* (model 5.) Suppose *this* was laid down on its side, leaving the cut-off valve in that position, and then a slide valve at each end to distribute the steam, and then a cut-off valve in the middle that distributed the steam?

A. Yes, sir.

439 x Q. Was that a detachable cut-off or slide?

A. Slide.

440 x Q. Covered its port by the motion of the eccentric?

A. Yes.

441 x Q. Did you ever ascertain what proportion of the power that was due to the steam used in the old arrangement was actually used upon that engine by indicator cards?

A. Yes.

442 x Q. How much did that arrangement diminish the value of steam between the boiler pressure and the result of the engine?

A. Only 54 lbs. in the cylinder, when it was 80 lbs. in the boiler?

443 x Q. Do you know what proportion of the actual theoretical power that was due to the steam was obtained by the use of that slide valve distributing cut-off?

A. I cannot tell.

444 x Q. It was a trip cut-off?

A. No.

445 x Q. On this engine (Corliss') do you know what proportion of the theoretical power was obtained?

A. We could get very nearly the whole power.

446 x Q. The valve cut off instantaneously upon your engine?

A. Yes.

447 x Q. There was no loss on the cut-off?

A. No.

448 x Q. Did you ever endeavor to find out what proportion of the saving that you realized was due to the use of the trip cut-off, and what proportion was due to the application of the governor to the cut-off instead of the throttle valve?

A. I never did myself. Mr. Corliss had his indicator put on to try an experiment.

190 449 x Q. Did you ever use your engine with the governor applied to a throttle valve, and Sickles' cut-off set upon it?

A. No, sir; I never did.

450 x Q. You never found out how much was due to the application of the governor, and how much was due to the application of the Sickles cut-off?

A. No.

Redirect.

451 Q. You say that the indicator showed rarely more than 54 lbs. pressure within the cylinder when there was 80 lbs. in the boiler?

A. Yes, sir.

452 Q. So that, after passing through the throttle valve and entering the cylinder, and acting in the cylinder, your pressure changed from 80 lbs. in the boiler to 54 lbs. there?

Q. Yes, sir.

453 Q. (By Mr. Dickerson.) I think you said you were cutting off by the old style at $\frac{1}{3}$. Now, where do you cut off?

A. I cannot say, sir; it varies all the time.

454 Q. You are cutting off short, are you not?

A. Yes, sir; very short.

455 Q. How much is about the range it goes to now, running down, following with the whole load on?

A. I should think about a foot—not quite a foot, as a general thing. That would be the maximum.

456 By Mr. Stoughton: How far have you ever known it to run at any particular time?

A. The whole length.

457 Q. Suppose you had a fixed cut-off, for the purpose of starting your work into operation, and that fixed cut-off had been placed so that it would run far enough to accomplish that, where would your fixed cut-off be placed?

A. Not anywhere, sir.

458 Q. When you work with a fixed cut-off, you adapt your cut-off to the maximum work you have to do?

A. Yes, sir.

459 Q. And regulate between that and the least amount of
191 work you have to do, with the throttle valve, by wire-drawing the steam?

A. Yes, sir.

460 Q. When work has been thrown off or put on the new engine,

what difference have you observed in the uniformity of motion of the machinery and engine?

A. I have never observed any difference among the machinery. I never would know of any variation by the running of the machinery; but on the engine I could see a longer cut-off or shorter.

By Mr. Dickerson:

461 x Q. You said your engine went full stroke sometimes?

A. My meaning was, when putting the load on, until we ran it sometime, a little while before we attached our governor to it, we ran it by the screw valve; then it would run the whole length.

462 x Q. I understand that when you started up your engine, and unscrewed your steam valve to get steam, it would go full stroke?

A. Yes.

463 x Q. And as soon as she gets velocity, she sets her balls out, and cuts off at about a foot?

A. Yes, sir; I should say at from four inches to six inches; as a general thing, about nine or ten inches.

464 x Q. And that operation is kept on, varying from four to ten inches through the day?

A. Yes, sir.

By Mr. Keller:

465 x Q. How often does it occur that you have to change materially the speed of the engine?

A. We change it not at all, sir, except on Saturday afternoon, in cleaning up; we sometimes shut our dampers.

466 x Q. You have a given number of spindles. Is it your practice to run all the spindles?

A. Yes, sir.

467 x Q. Does not that require a constant power—that is, the spindles, when all at work, require the same amount of power?

192 A. Yes, sir. Once or twice a day we stop all our mules. That may make a variation from ten to six inches.

468 x Q. Has there been no change or resetting of the boilers?

A. There has, sir.

469 x Q. Did not that take place at the time of putting in the new engine?

A. No, sir.

470 x Q. When Mr. Corliss put in the new engine are you positive there was no change made in the furnaces of the boiler, or in the boiler of any kind?

A. No, sir. In the steam pipe there was.

471 x Q. What was the difference of distance between the old engine and the boiler and the new engine and the boiler?

A. About 150 feet, sir.

By Mr. Stoughton:

472 Q. How far do you say the old engine was from the boiler?

A. About thirty feet.

473 Q. At this time how far is the new engine from the boiler?

A. About thirty-seven feet.

474 Q. When the change was made, before your boilers were reset, how far did you set the new engine off from the old boiler?

A. About 180 feet.

475 Q. Now, it turns out that the old engine was about thirty feet off from the boiler; your new engine at present is about thirty-seven feet off; and when you first began to run the new engine it was 180 feet off?

A. Yes, sir.

By Mr. Dickerson:

476 x Q. When your engine was 180 feet from the boiler was there any perceptible diminution of tension of steam between the engine and boiler?

A. I thought there was, sir.

477 x Q. How much?

193 A. I cannot say how much. We did not get as good results as when we reset our boilers.

478 x Q. I speak of the tension of the steam. Was there any loss of tension? How much was the pressure in the boiler and in the engine?

A. It showed the same pressure in the engine as in the boiler.

479 x Q. The difference in distance between the engine and the boiler, then, was unimportant?

A. No, sir; the pressure was the same in the engine, but there was not the expansive force of the steam.

480 x Q. When you came to pay Corliss for the saving did you not pay him on the saving ascertained at the time the boiler was so far away from the engine?

A. Yes, sir.

481 x Q. You say the tension of steam in the cylinder was as great as the tension in the boiler by the indicator?

A. Yes, sir.

482 x Q. But you are of opinion that that kind of steam was not as valuable as if it had come from a nearer place?

A. Yes, sir; my meaning is that there was not the expansive force in the steam, after remaining so long in the pipe, as if it were taken directly.

483 x Q. You mean to say that pressure at 85 lbs. in the cylinder has not the same expansive force, coming 180 feet, as if it came through 37 feet pipe?

A. Yes, sir.

484 x Q. Did you make any alteration in the boiler when you came to set them, or only remove them from one place to another?

A. That was all, sir. We made no change.

EDWARD S. LESLIE sworn.

Examined by Mr. Stoughton:

485 Q. What is your employment, and where do you reside?

A. I reside in Newburyport, and have charge of the Ocean Steam Cotton Mills.

486 Q. You have charge of it as superintendent?

A. Yes, sir.

194 487 Q. How long have you had charge of it?

A. About 6½ years.

488 Q. How many spindles do you run there?

A. A little short of 10,000.

489 Q. What is your motive power?

A. Steam.

490 Q. What engine do you use?

A. The Corliss engine.

491 Q. With his mode of regulation upon it?

A. Yes, sir; cutting off at the steam valve.

492 Q. When was it put up?

A. About four years ago.

493 Q. Did that engine replace any other; and if so, what?

A. It replaced Tufts' engine.

494 Q. What was the character and condition of Tufts' engine by comparison with best known at that day?

A. It was considered to be the best in use.

495 Q. What was the condition of the particular engine when taken out?

A. It was as good as new, with the exception of a little wear.

496 Q. How long had you used it?

A. About 10 years.

497 Q. What was its comparison as to working order and economy with what it had been at any previous time?

A. About the same. The consumption of coal was about the same as it always had been.

498 Q. What was the size of the Tufts engine?

A. 15-inch cylinder, 4½-feet stroke, double cylinder.

499 Q. How was it regulated?

A. In the usual way at that time by the throttle valve.

500 Q. Did you use the cut-off?

A. Yes, sir.

501 Q. And with that engine at what point did you cut off?

A. Pretty near one-half the stroke.

502 Q. Did you make any effort to gain more by the use of the expansive force cutting off shorter?

195 A. We tried some experiments; it did not work so well.

503 Q. What led you to make those experiments?

A. I was under the impression it would make more economy to cut off shorter and use steam more expansively.

504 Q. You found you were obliged to come down to almost half stroke?

A. Yes, sir.

505 Q. What was the effect of trying to cut off short?

A. We could not manage to run so regularly or have so good speed.

506 Q. You had to adopt your cut-off to the maximum work you were doing?

A. Yes, sir.

507 Q. Now, what quantity of coal did you use with that engine per day?

A. Well, we averaged 6,000 lbs. a day.

508 Q. What was the size of engine put in by Mr. Corliss?

A. 20-inch cylinder and 4-ft. stroke.

509 Q. A single cylinder?

A. Yes, sir; I was afraid I would not get as good speed with one cylinder.

510 Q. What was the regularity of your old machine, and how high could you run your looms?

A. Well, I used to run our looms about 126 picks per minute; that was the highest.

511 Q. Why was that the highest you could run them?

A. If we speeded our engine above that she did not regulate so well, and did not run uniformly.

512 Q. She would vary in velocity, and run them up too high?

A. Yes; did not run regularly.

513 Q. After you got them up too high, what was the effect upon the looms?

A. Unless our looms were adapted to that speed the shuttles would fly out.

514 Q. Upon the introduction of the Corliss engine, what is your consumption of coal per day?

A. 4,200 lbs.

515 Q. And what is the comparative work done?

196 A. We are doing rather more work.

516 Q. And what is the comparison, in point of regularity, between the two?

A. We have more perfect speed; we have been able to speed up our looms to as high as 133 picks.

517 Q. In consequence of the greater regularity?

A. Yes, sir.

518 Q. What is the difference between the production by the old and new engine operating your machinery; what per cent. do you gain?

A. We used to consider 36 thousand yards a week pretty good; now we get 40,000; we gain in that proportion.

519 Q. What difference did your waste account show between using the new and the old engine?

A. I do not know that there is any difference in that; that depends on the quality of material used.

520 Q. Are the boilers the same you used with the old engine?

A. Yes, the same.

521 Q. In the same condition?

A. Yes, sir.

522 Q. Was there any resetting?

A. No, sir; there was nothing changed when we put in the new engine. We use the same fly wheel, boiler, and steam pipe.

523 Q. Have you had occasion to throw off work from this engine at once?

A. We throw off a large part on Saturdays when cleaning.

524 Q. What was the effect on the speed of the engine?

A. I could not perceive any difference. I had on one occasion a belt break that threw the shafting off for half the mill, and the overseer standing behind the machinery at the other half, did not know it was broke.

By Mr. Keller:

525 x Q. Do you testify that of your own knowledge?

A. No; the overseer told me.

197 By Mr. Stoughton:

526 Q. Did you ever stand by the machinery when work was thrown off with your watch in hand to time it?

A. Yes, sir.

527 Q. What proportion of the work have you had thrown off at the time you stood with your watch to time it?

A. Perhaps about a quarter part.

528 Q. What difference did you ever discover in the revolutions of the fly wheel?

A. I couldn't discover any. I counted it when we ran forty-eight revolutions, and it did not vary any that I could perceive.

529 Q. Did anything lead you to make this change of the Corliss engine for the other?

A. Yes, sir; they had been making changes at other mills and I saw great saving. Our directors were very loath to make the change, because the engines were considered too good to throw away; when they came to see the result of saving in the other mills they consented.

530 Q. On what terms did you get the new engine?

A. For the old engine and the saving of fuel in two and half years, or $3,000 in cash and the old engine.

531 Q. What arrangement did you make?

A. We paid him the cash.

532 Q. What has been your saving?

A. We saved it in about three years, at the rate we were paying for fuel at that time.

533 Q. Was any attempt made at the time you threw Tufts' engine out to attach any governor to the steam valves of the engine?

A. No, sir.

Cross-examined by Mr. Dickerson.

534 x Q. You heard the testimony of Mr. Stearns?

A. Yes, sir.

535 x Q. Your engine was the same as the one he described?

A. Yes, sir.

198 536 x Q. The same construction—a slide valve cut-off in the middle, and a separate slide at each end?

A. Yes, sir.

537 x Q. At what point does the engine now cut off?

A. I should think from six to eight inches.

538 x Q. The stroke of the engine is four feet?

A. Yes, sir.

539 x Q. In the old engine you cut off at half stroke?

A. Yes, sir.

540 x Q. How fast does this engine run?

A. Forty-eight revolutions.

541 x Q. And the old one?

A. Thirty-five revolutions.

542 x Q. What was the size of the old engine?

A. Fifteen inch cylinder, four and a half feet stroke, two cylinders.

543 x Q. Non-condensing engine, high pressure?

A. Yes, sir.

544 x Q. You never got much steam in the boiler in the old engine. How much in the boiler?

A. Eighty pounds in the boiler.

545 x Q. How much in the engine?

A. Forty-seven pounds.

546 x Q. Now you carry what steam?

A. Eighty pounds.

547 x Q. And cut off at from six to eight inches?

A. About that.

548 x Q. Did you ever take any means to find out what was the cause of this economy, whether the Sickles cut-off or the application of the governor?

A. I should think the governor did the business.

549 x Q. You think it makes no difference on an engine whether it has a drop cut-off at the steam valve?

A. I think the governor must be attached to the steam valve instead of the throttle valve.

550 x Q. It must be a drop valve, too?

A. I think so.

551 x Q. You have got a saving of thirty per cent. To which part of the arrangement is it due? You have got an engine with two new things; one, the application of the Sickles cut-off, or trip

199 cut-off, with the slide valve. To which is it due, do you suppose, or in what proportion to either—to the trip cut-off, or the governor attached to the cut-off?

A. I do not think they could be separated.

552 x Q. Suppose the trip cut-off was attached to your engine at ten inches, and fix it there, then you would have enough and to spare; then put the governor behind that, to wire-draw it down; how much difference would that produce in your economy?

A. I do not think it would produce as much as now.

553 x Q. Have you ever tried the experiment?

A. No, sir.

554 x Q. Suppose you put the governor to the throttle valve and set your trip cut-off with the slide valve at ten inches, what difference would that make in the economy?

A. I do not know what difference it would make, but I do not think it would produce the same effect as now. I do not see how it could, unless the governor was attached to the cut-off valve.

555 x Q. Ten inches gives you power enough?

A. Yes; but there you are limited.

556 x Q. That ten inches is one-fifth of your stroke; then you are always getting steam expanded five times. On the former occasion you had economy due to one-half the cut-off. Put the governor on the outside of that; all the governor could do would be to reduce the tension down to one-fifth, at which to do your work?

A. My opinion is, that you require the whole power of the boiler on to the cut-off valve.

By Mr. Keller:

557 x Q. How often did you throw off any important portion of the machinery in your mill?

A. About twice a day.

558 x Q. How long a time does each change take place?

A. About twenty minutes.

By Mr. Stoughton:

559 Q. I understand you to say you carry 80 lbs. pressure in the boiler, and that you never get into the cylinder, before cutting off steam, more than 47 or 48 lbs?

200

A. Yes, sir.

560 Q. Then the difference between the pressure in the steam and in the boiler was at 47 or 48 lbs. to 80 lbs.?

A. Yes, sir.

561 Q. Do you suppose that if you had a different drop valve it would have been any greater pressure?

A. Not with the throttle valve.

By Mr. Dickerson:

562 x Q. In the old engine, the throttle valve would stand wide open at times?

A. Yes, sir.

563 x Q. Did that wire draw any steam when wide open?

A. No, sir.

564 x Q. You could get but 47 or 48 lbs. when the throttle valve was wide open?

A. Oh, yes, sir. The throttle valve was nearly close down when running.

By Mr. Stoughton:

565 Q. Did you run your engine with as short a cut-off as you could possibly and keep good speed.

A. Cutting off at half stroke we could keep up pretty good speed.

566 Q. You ran your engine in the best way you could, using the throttle valve?

A. Yes, sir.

567 Q. Did you think that was a good throttle valve?

A. As good as could be made.

568 Q. What kind of throttle valve was it?

A. The same as any; as good as made.

STEPHEN CORNELL sworn.

Examined by Mr. Stoughton:

569 Q. What is your employment, and where do you live?

201 A. In Providence, R. I. I am superintendent of the Providence Dyeing, Bleaching, and Calendering Co.?

570 Q. How long have you been employed in that way?

A. Something over twenty-nine years.

571 Q. What motive power do you use there?

A. Steam, sir.

572 Q. What kind of engine?

A. The Corliss engine.

573 Q. When did you first put up the Corliss engine, with method of regulation by the steam valves in that concern?

A. In February, 1848.

574 Q. You put up your first engine then?

A. Yes, sir.

575 Q. About how many horse-power was that engine?

A. About 250, I guess

576 Q. Do you recollect when you made your contract for that engine?

A. In the summer of 1847, I think. I do not now recollect the date.

577 Q. Do you recollect whether that was the first engine ever put up by Mr. Corliss with that mode of regulation?

A. I think it was, sir. It was the first I ever knew.

578 Q. What engine had you previously used there, and with what mode of regulation?

A. We had a horizontal engine—24½-inch cylinder, 10 feet stroke.

579 Q. Was it an engine built for your works?

A. No; a second-hand engine, that had been used in the segar boat.

580 Q. What mode of regulation did you have on that?

A. The old method of regulation with the fly-ball governor.

581 Q. About what time in February, 1848, was that engine put in operation by Mr. Corliss in your mill?

A. About the middle of February.

582 Q. And from the time it was put in operation, how did it operate; how did it regulate?

A. It operated entirely satisfactory for us, and regulated well. The regulation was considered about perfect.

202 583 Q. From the time it was first put up and set in operation for you?

A. Some few days' time elapsed before the regulation to which the governor was attached was in perfect order. We were in a hurry to get it up.

584 Q. From the time the governor was attached and the regulation complete, what was its regulation?

A. It was as near perfection as I ever expect to get.

585 Q. Did it attract particular attention there?

A. Yes, sir.

586 Q. A good many went to see it?

A. Yes, sir.

587 Q. What was the operation of the engine when you threw off large quantities of work?

A. We could not discover any difference.

588 Q. What proportion of your work did you ever throw off at a time to try the experiment of regulation?

A. At 12 o'clock the machinery would be almost all thrown off; all down to the shafting was thrown off as near together as the men will go to dinner together.

589 Q. Did you ever watch the engine when that has been done?

A. Yes, sir.

590 Q. What effect did you discover, if any?

A. I could never discover any to the eye, nor to count. In a quarter of a minute it kept up its number of revolutions.

591 Q. How did that compare with the throttle valve regulation you had before?

A. The throttle valve regulation was as bad as it could be, with our machinery. Our machinery was heavy, and changing many times a day—losing 20 horse-power every 20 or 25 minutes perhaps. We had some machinery we never allowed to run without an engineer standing at the screw valve, to shut the steam off.

592 Q. That was necessary with the old engine?

A. Yes, sir.

593 Q. Did that necessity ever occur with the new?

A. No, sir.

594 Q. What change was effected, if any, in the burning of coal, do you recollect?

203 A. With the old engine we were running we burned about 9 tons a day; with the new engine 6 to 7 tons—the extent 7.

595 Q. How does the amount of work done with the new engine compare with that done by the old?

A. We got more work because we had uniform speed.

596 Q. How long did that engine, in that form, run in your mill?

A. About 7 years.

597 Q. What occurred then?

A. It was broken up. I do not know positively how. No one was in the engine room when we broke. We always supposed the crank gave way.

598 Q. Was it repaired, and the invention of Mr. Corliss again applied to it for regulation?

A. All remaining parts of the engine were allowed to remain, and an engine of Mr. Corliss was put in its place, of smaller dimensions, and different arrangement of valve gear.

599 Q. Using the regulation of the cut-off valve as before?

A. Yes, sir.

600 Q. The first regulation had the helical cam?

A. Yes.

601 Q. And the next had the wrist-motion there, with latches?

A. Yes, sir.

602 Q. The means of regulation by the governor, with the stop?

A. Yes, sir.

Cross-examined by Mr. Thurston.

603 x Q. In what place did you obtain the old engine?

A. I suppose Mr. Clarke, our engineer, went to New York to purchase it.

604 x Q. It was purchased as a piece of second-hand property in N. York?

A. Yes, sir.

605 x Q. It came from a vessel that was wrecked?

A. Yes, sir.

204 606 x Q. It was built for a marine engine?

A. Yes, sir.

607 x Q. You have said it was 24½-inch cylinder and 10 feet stroke. When you first set the engine up what sort of cut-off was it provided with?

A. I do not recollect. I know afterwards Mr. Barber altered the cut-off for one of his invention.

608 x Q. Was Barber's cut-off on at the time Mr. Corliss took out the engine and substituted his?

A. Yes, sir.

609 x Q. State of what character the Barber cut-off is, and whether it operated by a cam.

A. Yes, sir.

610 x Q. And is the valve located in the steam-pipe?

A. No, the steam-chest.

611 x Q. How was that operated?

A. By a cam on the shaft.

612 x Q. Was it the main steam valve, or another valve beyond that, that distributed the steam to the cylinder?

A. My impression is that there was a separate valve in the steam-chest.

613 x Q. Do you speak from impression or from positive recollection?

A. My recollection is not positive on that point.

614 x Q. What kind of valves did the engine have?

A. Slide valves.

615 x Q. Have you any doubt whether this cut-off valve had another valve besides that?

A. I am not positive of that.

616 x Q. You are not quite sure whether the slide valves were also cut-off valves or not?

A. No, sir. My impression is that there was another valve.

617 x Q. I understand you to say there was also a throttle valve regulation?

A. Yes, sir.

618 x Q. What was the distance of the engine from the boiler?

A. About 120 feet

619 x Q. Was any difference made when you put in Corliss'?

205 A. About 10 feet.

620 x Q. Any difference between the form of the steam-pipe in the old and in the new engine?

A. The same pipe, sir.

621 x Q. Did you use steam out of the boiler for any other purpose before the introduction of the new engine?

A. We had two boilers, and used them both before and after for dyeing purposes.

622 x Q. Independent of the boilers that supplied steam to the engine?

A. Yes. The same number of boilers for the engine in both cases.

623 x Q. Tell us how the piston in the old engine was packed?

A. The old style of metallic ring—the same in use generally.

624 x Q. Did it leak steam pretty badly?

A. Sometimes.

625 x Q. Was there not, in fact, before the introduction of Mr. Corliss' engine, a good deal of trouble by leaking?

A. I do not think there was. When it got worn pretty badly we had another set made. We had seven sets made in the course of the operation of the engine.

626 x Q. How high did you carry steam in the old boiler?

A. We carried from 70 to 30 pounds. About 40 pounds was her range.

627 x Q. This engine went to pieces without any known cause, and the new one was put in its place?

A. Yes, sir.

By Mr. Stoughton:

628 x Q. After 7 years?

A. Yes, sir.

By Mr. Dickerson:

629 x Q. What was the point of cut off?

A. I do not recollect. I think about half stroke.

630 x Q. Where did the new one cut off?

206 A. The new one cut off at no definite point. The average was about 8 inches to 2 feet. The average most of the time 12 inches.

631 x Q. When you went full stroke with the engine did you go as economically as with the old one?

A. A great deal more so; because we were enabled to drive all our load.

Adjourned to 9 a. m. to-morrow.

SATURDAY, *Sept. 22d*, 1860.

The court met at 9 o'clock a. m.

WILLIAM H. MERRILL called by plaintiff and sworn.

Examined by Mr. Stoughton:

632 Q. Where do you reside, and what do you do?

A. In Taunton, Mass. I am employed as master mechanic of Crocker & Bro.'s rolling-mill.

633 Q. What material do you roll there?

A. Copper and yellow metal.

634 Q. What sizes and weights?

A. We roll various sizes. Our heft runs from 1,100 or 1,200 downwards to any heft under 1,200 in copper or yellow metal in one sheet.

635 Q. What motive power do you use?

A. Steam.

636 Q. What engine?

A. George H. Corliss'.

637 Q. With his regulator?

A. Yes, sir.

638 Q. Cutting off at the steam valve?

A. Yes, sir.

639 Q. How long have you used it?

A. We have used it since 1852.

640 Q. Before that time what did you use?

A. We used a beam condensing engine.

641 Q. What mode of regulation did you have on it any time before you adopted Mr. Corliss'?

207 A. When we first put the engine up we had a governor attached to the throttle valve. There were two throttle valves. The one between the outer throttle valve, or the throttle valve nearest the boiler and the valves, was regulated by the governor, acted upon by the fly-ball governor.

642 Q. How did you regulate the other throttle valve?

A. The other was regulated by hand.

643 Q. Why did you have the other regulated by hand?

A. Because the fly-ball governor could not regulate to give us any uniform speed.

644 Q. What did your man do to regulate it?

A. We had a long rod that came down close to the rock shaft. He stood there with his hand, and gave more or less steam as the velocity required.

645 Q. By that mode of regulation with the throttle valve and hand, too, what variation would occur in your engine per minute?

A. It is so long ago that I cannot just state; but there was, under different circumstances, a very great difference—some eight or ten turns in a minute, under the different circumstances of the power applied.

646 Q. What is your practice in that mill as to throwing off your work suddenly from the engine?

A. We are liable to throw the whole of the rolling off at any moment, or part of it.

647 Q. What work, requiring what horse-power, would you throw off, if you threw the whole off?

A. I do not really get your idea.

648 Q. What horse-power is required to do all your work?

A. We are subject to a strain, or, at least, we had strains of some 400 horse-power, as given by the indicator. Our usual strain is from 100 to 250 horse-power.

649 Q. Throwing part of your work off, what number of horse-power are you liable to throw off?

A. We are liable to throw the whole off at any moment.

650 Q. With the Corliss engine do you have any man to assist in the regulation?

A. We do not.

208 651 Q. And what is the regulation effected by the engine in the operation of working your machine? How much does it vary, if any?

A. The speed we run at is 33 revolutions per minute, and I do not ever recollect seeing it, on a count, below 32 or over 34.

652 Q. When all your machinery has been thrown off at any one time, were you able by the eye to detect a difference in the movement of the fly-wheel?

A. Yes, sir; a slight variation.

653 Q. If you noticed it in the fly-wheel, would you notice it in the machinery?

A. A person not practiced would not, but a person well acquainted and practiced might detect a slight variation, but not much.

654 Q. What are the variations in work to be done which produce a difference of one or two turns in the fly-wheel?

A. If we are drawing out a piece of metal 20 feet long, we give it four passes: First, when commencing, 16 feet long, and, when ending, 20 feet. It is 18 oz. to the superficial foot. When we break this down or roll it down 20 feet long, the last time it goes through, you find about as much variation then as at any time. There would be a momentary slack or retardation in the motion, and then comes up again the next.

655 Q. As I understand, you go suddenly from 60 or 100 horse-power up to 200 or 260?

A. Yes, sir. The friction of the mill is sixty horse-power.

656 Q. And you go from that up to the whole of your work, and the whole work is thrown off suddenly?

A. We are liable to that.

657 Q. When that change occurs, do I understand you to say you never knew of any difference greater than one or two revolutions of the fly-wheel in the minute?

A. No, sir; I never did.

658 Q. Has any change taken place in the amount of work you were able to do in consequence of this greater regularity?

209 A. There is. We do about one-third more work by the same machinery; from one-fourth to one-third more work.

659 Q. What was the size of your old engine?

A. Forty-two-inch cylinder, seven feet stroke.

660 Q. What is the size of your present engines?

A. Thirty-two-inch cylinder and six feet stroke.

661 Q. Did you use the same boilers that you do now?

A. Yes.

Cross-examined by Mr. Dickerson.

662 x Q. What was the description or quality of that old engine you took out?

A. It was a beam condensing engine; an old-fashioned slide valve engine—D valve.

663 x Q. Was it not an old Bolton & Watt engine?

A. I suppose it was.

664 x Q. Did you have any cut-off on it?

A. No, we did not.

665 x Q. The old Bolton & Watt engine, without a cut-off?

A. Yes, sir.

666 x Q. You say you are a machinist?

A. I am not a machinist.

667 x Q. Are you familiar with the problem of regulating machinery driven by steam?

A. Perhaps I may be in some cases. I am not an expert in engines; I have run engines myself, and had care of three for some ten years.

668 x Q. Is there any difficulty about regulating an engine within two turns in a minute by the throttle valve?

A. I think there is in a rolling-mill—I know there is. You mean attending it by hand?

669 x Q. No, by the throttle valve governor attached.

A. It was impossible with us to do it. Perhaps others could.

670 x Q. What kind of arrangement was your throttle valve arrangement on this engine?

A. It was a throttle valve attached to the fly-ball governor.

671 x Q. Is that the only way you ever saw it tried to regulate by a throttle valve?

210 A. The only way I ever saw our rolling-mill.

672 x Q. Is there any difficulty in regulating that machinery within two turns a minute by the throttle valve?

A. We have an engine we run (cupola furnace,) and we have no difficulty in regulating that by a throttle valve. We run at such speed as we wish to have it.

673 x Q. Your engine runs wide open under some circumstances—full stroke?

A. When we have steam on, she always cuts off.

674 x Q. What is the range between doing your heavy work and light work, rolling out sheet?

A. That would be impossible for me to tell. The inclined plane varies one and a half inch or two inches.

675 x Q. That is, the inclined plane that the governor operates?

A. Yes, sir. It varies from one and a half to two inches when we get our extreme work on.

676 x Q. The inclined plane varies from one and a half to two inches, yet your engine only varies two turns in a minute?

A. I made the statement that I never saw it vary from more than thirty-two to thirty-four in a minute.

677 x Q. Take any three strokes and the three which follow it?

A. I never went into it so minutely as that. I never watched it any one time short of half a minute, and I never saw a greater variation than what I tell you. Perhaps by taking the whole minute she would come up to her regular run.

678 x Q. What is the whole length of your slide motion?

A. I should judge it was four or five inches incline.

679 x Q. And the variation is from one and a half to two inches?

A. Yes, sir.

680 x Q. Court: What is the comparative effect on wear and tear of your machinery under the regulation by Corliss' engine and the old engine?

A. The wear and tear of our machinery is nothing like so bad
211 as it was before. It used to retard before so much that we had to put on all the steam we could.

EDWIN J. NIGHTINGALE sworn.

Examined by Mr. Stoughton:

681 Q. Where do you reside, and with what concern are you connected?

A. I reside in Providence. I am treasurer of the Corliss Steam Engine Co.

682 Q. Is that the company that builds these engines with Corliss' improvement?

A. It is.

683 Q. When was that concern started for the purpose of building these machines?

A. We built our present concern in the year 1848 or '49, immediately after, or pretty soon after, the calendar engine was started; we built it for the purpose of building that particular kind of machine.

684 Q. The calendar engine testified to yesterday by Cornell?

A. Yes, sir. We were carrying on business in the old establishment previous to that.

685 Q. About how many have you constructed and sold since then upon that plan?

A. I should judge over 300 of them.

686 Q. Have you any interest in the patent of Mr. Corliss?

A. I have not; the patent belongs to Mr. Corliss exclusively, and the company pay him for the use of it, for every engine we build.

687 Q. About how many of these have been built and put into establishments to replace others taken out?

A. I think more than 100 in that way.

688 Q. Do you know Mr. Noble T. Green?

A. I do.

689 Q. Was he at any time connected with a concern in Providence?

A. He was; with the concern of Thurston, Green & Co.?

690 Q. When was it Thurston, Green & Co.?

A. I suppose 10 years ago; I do not know how long it continued so.

212 691 Q. About how long?

A. For a number of years it was Thurston, Green & Co.

692 Q. Beginning 10 years since?

A. Yes, sir; it may have begun earlier, but 10 years ago the concern was of that name.

693 Q. Among the engines your concern has built, have they built any to replace engines taken out, constructed, under the Sickles patent—the Sickles cut-off and throttle valve regulator?

A. We have.

694 Q. How many of those engines with the Sickles cut-off have you replaced by your engines, and in what mills?

A. I recollect now seven of them we have replaced. I have a memorandum of some. The Pokanoket steam mill, at Bristol, had an engine 23-in. cylinder and 5 ft. stroke, puppet valve, and Sickles' cut-off. It had a regulator acting on the throttle valve.

695 Q. What kind of throttle valve?

A. Most of those engines of the Sickles cut-off that we took out had the register throttle valve. I am not sure whether that one had the register or other kind of throttle valve.

696 Q. From your knowledge of machinery, what was then considered the best kind of throttle valve?

A. The concern that built the Sickles engines used the register throttle valve, and from that I presume they considered that the best. We never made any in that way.

697 Q. When did you take that out of the Pokanoket mill?

A. In 1855.

698 Q. What size did you put in?

A. We put in an engine cylinder 20 inches and 4 feet stroke, with the Corliss cut-off.

699 Q. Was there any change of the boilers?

A. No, sir. Previous to our making the contract with them they had reset their boilers, and had examined the engine and put it in order. They reset and put the boilers in as good order as they could, and ran the other engine several months before we took it out.

700 Q. On what terms was yours put in?

213 A. We were to get $5,000, or the saving in fuel for five years.

701 Q. What did they pay you?

A. They had the privilege of trying it as long as they chose. They ran three months, and paid us $474 for the saving of fuel in those three months, and paid us, in addition, the $5,000.

702 Q. Did you replace Sickles' cut-off in the Washington Manufacturing Co. at Gloucester, New Jersey?

A. We did.

703 Q. Give us the size of the Sickles engine there.

A. The engine we took out had 42-inch cylinder and 5 feet stroke—puppet valves. The one we put in had 32-inch cylinder and 7 feet stroke, with the Corliss cut-off.

704 Q. On what terms were you to be paid for doing the same work?

A. They were using with the other engine 8 to 9 tons of coal per day, on the average. We agreed to put in a new one, guaranteeing that it would run with not exceeding 4 tons per day, or that we would forfeit $5,000 per ton for any excess over 4 tons. If the engine used more than 4 tons, we were to pay $5,000 per ton for the excess over 4 tons.

705 Q. And in that proportion if it used a fraction of a ton more than 4?

A. If it used a fraction of a ton more than 4 we were to pay in that proportion.

706 Q. Were you called upon for any forfeiture?

A. We were not. The engine came within our guarantee.

707 Q. Who made the engine you took out?

A. I. P. Morris & Co., Philadelphia.

708 Q. In the Rockport steam mill, Mass., did you replace a Sickles cut-off, having the throttle valve regulator?

A. We did: we took out the Sickles cut-off.

709 Q. Whose make was that?

A. By I. P. Morris & Co., Philadelphia.

710 Q. What was the size of the cylinder?

A. 30-in. diameter, and 5 feet stroke.

711 Q. What size was the cylinder you put in?

A. We put in a pair of cylinders, 20-inch diameter, 4 feet stroke.

214 712 Q. On what guarantee of saving did you put that in?

A. Our contract was that we were to receive either $15,000, or the saving of fuel in 5 years, giving the parties the choice. They paid us $15,000, preferring to pay us in that way than by 5 years' saving.

713 Q. Did you replace one of the Sickles cut-off engines in the Franklin foundry, Providence?

A. We did.

714 Q. When was that?

A. That was in 1856.

715 Q. Who made that Sickles engine?

A. Thurston, Green & Co.

716 Q. And what was the diameter of cylinder?

A. I have not a memorandum of the size of that engine. It was in the neighborhood of 15 or 16 inches—I think 16 inches; and we put in a 14-inch cylinder.

717 Q. On what terms did you put it in?

A. Our regular price for an engine of that size; and they saved about half their fuel.

718 Q. Did you replace a Sickles engine for the New England Butt Co.?

A. We did, in Providence.

719 Q. Who made that engine;

A. Thurston, Green & Co.

720 Q. When did you replace it?

A. In 1855.

721 Q. The size of the engine you replaced?

A. I believe the size of that was 18 inches. We put in a 16-inch cylinder—the same length of stroke—3½ ft. stroke in both cases. The contract with them was that they were to pay either our regular price, or five years' saving of fuel; and they decided to pay us our regular price for the engine.

722 Q. Did you replace a Sickles cut-off for John Goram, of Providence?

A. We did, in 1855.

723 Q. The size of the Sickles machine?

A. It was a fifteen-inch cylinder. We put in place of it a 14-inch cylinder—the length of stroke the same.

724 Q. Who made it?

215 A. It was made by Thurston, Green & Co.

725 Q. On what terms?

A. On the saving of coal in 5 years.

726 Q. Did you receive your pay in that way, or the regular price?

A. We received payment in the saving of fuel in five years. It is not entirely settled yet, as the five years are not up.

727 Q. What did you get out of it?

A. We got a very fair price for the work. It pays, I think, more than if we got our regular price for it.

728 Q. Did you replace one of the Sickles engines with one of Corliss' for the Atlantic Delaine Works?

A. We did.

729 Q. Where was that located, and who made the engine?

A. It was located at Olneyville, out of Providence; made by Thurston, Green & Co.

730 Q. Do you know the size of that?

A. We took out two cylinders, 42-in. diameter, and 5 ft. stroke each, and put in place of them one cylinder, 32-in. diameter, and 7 ft. stroke.

731 Q. What were the terms?

A. They informed us that they used on the average six tons of coal per day for power, exclusive of heating, and our guarantee was to

do the work for three tons a day, instead of six, or forfeit a dollar a pound for anything over three tons. We also guaranteed the speed. They had been troubled a good deal with the speed not being regular. We guaranteed to give them as regular and perfect a speed as they could find in any mill using water or steam power in this or any country.

732 Q. How did they regulate?

A. By the register throttle valve.

733 Q. How long had they been using the old engine?

A. 17 months, at the time we took it out.

734 Q. What was the cost of such an engine as that?

A. I understood the price paid for it was $30,000.

(Objected to.)

216 735 Q. About what would such an engine as that cost?

A. I should suppose that was a fair price for it.

736 Q. Who was that built by?

A. By Thurston, Green & Co.

737 Q. Did you have anything to pay on the guarantee?

A. No, sir; we came within our guarantees. The parties paid us up, and informed us we came within our guarantees.

738 Q. What did they pay you?

A. Our contract was the price they were to pay was $9,000 and the other engine, or $12,500 and to keep the other engine. They advertised the engines six months, and finally they were sold at auction, and we bid them in at $3,000.

739 Q. So you were paid your $12,000?

A. We were paid our $9,000 and the other engine.

740 Q. Did you replace any engine with yours in the James Steam Mill, at Newburyport, Mass.?

A. We did. It was a cotton mill of about 17,000 spindles.

741 Q. What did you take out?

A. We took out a pair of engines made by Fairbanks, Bancroft & Co.

742 Q. What was the size of the engine you took out?

A. We took out a pair of engines 24 inches diameter and 4 ft. stroke.

743 Q. What was the size of the engine you put in?

A. Two cylinders, 18-in. diameter and 4 ft. stroke—non-condensing.

744 Q. How did the old engine regulate?

A. By the throttle valve.

745 Q. Upon what terms did you put the new engine in?

A. They had the privilege of paying either the $10,500 or five times the first year's saving.

746 Q. Which did they elect to do?

A. They were by the contract to decide before starting which they were to do; and, as the other engines were running economically, they thought they would get an engine for very little, so they decided to pay five times the first year's saving. The result was that they paid us $19,734$\frac{23}{100}$, instead of $10,500.

217 747 Q. How many rolling mills have you supplied with your engines?

A. There are seven of our engines now running in successful operation in rolling mills, and we are making five other engines for rolling mills.

748 Q. You are acquainted with Mr. Corliss' invention, as modified with the wrist plate and valve gear, described in his patent of 1851?

A. Yes, sir.

749 Q. Such as is represented on that farther model?

A. Yes, sir; as the wrist plate attachment. Model C is another model without the wrist plate.

750 Q. When did Mr. Corliss build his first engine with the wrist plate and that mode of valve gear shown on "C?"

A. It was an engine we put in for Philip Allen, Print Works, North Providence, set in operation July 5th, 1849.

751 Q. Who did the boiler work for the engine that you put up with the wrist plate and that mode of valve gear?

A. Thurston, Green & Co.

Cross-examined by Mr. Dickerson.

752 x Q. You spoke of those engines that were taken off as Sickles' cut-off engines. Do you know anything about the machines yourself?

A. We have had the machines at our works, after taking them out and examined them, and we saw them running before.

753 x Q. You had taken indicator cards of those engines?

A. Of some of them indicator cards were taken.

754 x Q. Did you not of all of them?

A. I do not recollect whether we did upon all or not; on most of them there were.

755 x Q. Have you got any of these indicator cards now?

A. I have not any. I believe we have some at the works in Providence.

756 x Q. Could you have them produced?

A. I think we could.

757 x Q. Do you know anything about the difficulty in those engines that you were going to remedy by substituting another engine?

218 A. The difficulty was that they used too much fuel and did not run at regular speed.

758 x Q. That is the result; but do you know why the engines used too much coal?

A. I consider the reason is because they did not have a Corliss cut-off.

759 x Q. Tell us what a Corliss cut-off is.

A. It is a regulator attached to steam valves to disengage them, making a variable cut-off, as I understand it.

760 x Q. I speak of the cut-off, not the regulator. Is there any difference between the Corliss cut-off and the Sickles cut-off?

A. Yes, sir. The Corliss cut-off is a combination of the regulator

with a stop or cam to disengage the steam valve. The Sickles cut-off is a trip cut-off. That is one difference.

761 x Q. Can you tell any other difference?

A. I cannot go into details; I am not an expert. I attend to the financial matters of the concern.

762 x Q. Do you know any other difference beyond that?

A. All the Sickles cut-offs I have seen the valve drops. Ours do not. Ours slide.

763 x Q. One is a puppet valve, the other a slide valve. One uses the governor attached to the cut-off and the other does not put the governor to the cut-off. To which of these causes do you attribute the effect?

A. I suppose they all tend to make up the general result. I do not suppose it is owing to any particular one. I suppose it is the combination.

764 x Q. Do you know anything about the condition of those engines taken out?

A. I know the Pokanoket steam-engine was overhauled and repaired within two or three months of the time we took it out, and I know the Atlantic Delaine Co.'s engine was only running seventeen months, and ought to be good.

765 x Q. I want to know if you know anything of the condition in which they were?

A. So far as I know they ran as well when taken out as they had previously run. We were informed so by the parties who had them.

766 x Q. Do you know anything of their condition when taken out yourself?

219 A. I do not know, personally.

767 x Q. Do you know whether the valves were tight?

A. I do not.

768 x Q. Your valves in your engine were tight?

A. I should judge they were, because they saved so much fuel.

769 x Q. And the others you would judge were not tight, because they did not save so much?

A. I do not know. I suppose they were in as good order as at any time. My opinion is that puppet valves always leak more or less, or nearly always.

770 x Q. Do you know anything about that?

A. I am not personally acquainted with it. I know their striking down on to their seats tends to get the seats out of order, and I know they are frequently ground out.

771 x Q. Do not slide valves get to leaking?

A. I know they run in many cases five or eight years without leaking any. I know they generally run tighter after running two or three years than they do the first month.

772 x Q. Your slide valves are made upon a circle?

A. Yes, sir. We have made the flat slide.

773 x Q. You think the circular slide valve will grind itself tighter by use?

A. I think that after they are used a short time they will be per-

fectly tight. When first put in, the tool marks, in making them, may leak a very little.

774 x Q. In regard to the Delaine engine, do you know that the foundations of that engine had settled, so that they could not keep the two engines in line together?

A. I know that, after running awhile, they had made some repairs to the foundations.

775 x Q. Do you know they never had them so that they could run them well on those engines?

A. I do not know that. I know they cost a great deal more than the foundations we put in to take the place of them.

776 x Q. Can you fix in a circular slide valve so that, if it grinds, it will not grind the outside bigger and the inside smaller?

220 A. I have no doubt it varies a little, but the valve itself follows down on it.

777 x Q. Answer the question.

A. I have no doubt there is a very little wear in that way; but I know the practical result is that they work tighter after being used a few years than when put in.

778 x Q. How do you know?

A. Because the engine uses less fuel.

779 x Q. How do you apply that reasoning to the cases of engines you took out? Were those you took out tight?

A. I do not know.

780 x Q. If they were leaking badly they would leak all the difference you talk about. It is easy to make an engine leak half its fuel.

A. I never saw valves I thought would leak as much as that.

781 x Q. Take the Sickles cut-off; suppose the dash-pot is so set that the valve does not strike its seat, but is sustained in the dash-pot?

A. If the dash-pot is not on its seat, it might use double the fuel.

782 x Q. It is a question of construction whether you get a good or a bad one?

A. Yes; I know in the Pokanoket mill the builders had repaired the valves, and put it in as good order as they could within two or three months of the change. I did not see them repaired myself. I believe they were in as good condition as they ever were.

783 x Q. Who knows all about the condition of those engines?

A. I cannot tell you.

784 x Q. You are a partner of Corliss?

A. I am in the steam-engine business, but I have no interest in the patent. The concern of which I am a member pays Mr. Corliss individually for the use of his patent.

785 x Q. Has not your partnership an exclusive right to use this patent?

A. Mr. Corliss has the exclusive right, and he sells to other parties besides us. What he sells to others I receive nothing on; but we pay him for what we use it ourselves.

221 786 x Q. In putting in these engines you speak of, did you not accelerate the speed of the engines?

A. We did in some cases. I do not know whether we did in all or not.

787 x Q. In which one did you not?

A. There are several of them that I do not know the speed we ran them at. I am not sure whether the speed was changed or not.

788 x Q. Do you know they were not run faster?

A. There are some I know we did run faster; others I do not know whether we ran at the same speed or a different speed.

789 x Q. What is the effect of running an engine faster?

A. We get a better advantage from the fly-wheel.

790 x Q. You get more expansion, too, do you not?

A. I do not know that we do.

791 x Q. Suppose you ran your engine at twice the speed?

A. The amount of expansion depends on where you cut off.

792 x Q. But if you run quicker you can cut off shorter and get the same power?

A. Yes, we can; but in all these cases we put in smaller engines.

793 Q. The engine was made bigger by running faster?

A. Yes; we make up the size by running faster.

794 x Q. You make up for its being a smaller engine by running faster; would the same amount of expansion be had?

A. Where we take out a large engine and put in a smaller one, and run at quicker speed, that makes up for the difference of its being a smaller engine.

795 x Q. Where were the engines cut off that you took out?

A. I do not know.

796 x Q. Do you know where the engine in Gloucester mill cuts off?

A. I cannot say positively. My impression is that it follows one-sixth of stroke. I know most of our engines follow from $\frac{1}{4}$ to $\frac{1}{8}$ of the stroke.

797 x Q. You do not know where the old one was?

222 A. I do not.

798 x Q. Is there any difference that you know of after the valve is trippled until it closes its port—two valves closing their ports with equal speed? Is there any difference in the effect on the engine what kind of valve that is?

A. I believe that these slide valves are better than any other; but I cannot tell you exactly about those matters.

799 x Q. The old engine at the Delaine mill was running about 14 lbs. of steam?

A. I do not know.

800 x Q. Do you know how they carry steam there now?

A. They carry about 40 lbs.

The plaintiff rests.

223 REBUTTING EVIDENCE.

HENRY WATERS recalled by Mr. Stoughton:

1 Q. Be kind enough to look at the model of that so-called French machine, and state whether you are familiar with the drawings and description from which that model is supposed to have been made?

A. I am.

2 Q. Is that an exact representation of the machine described in these drawings and specifications?

A. It is not exact.

3 Q. Will you state to the court in what respect or respects that model differs from the description and drawings?

A. In the first place the connection between the sleeve of the governor and this pair of bevelled pinions, by means of two levers and the outside connections, being the connection from this sleeve, round up to the outside, and taking hold within, amounting in its action to precisely the same thing, giving about the same relative motion to the parts that it would without the levers. In connection with these levers there is an apparatus which I understand to be for the purpose of enabling the engineer to hold these balls in such a position that they shall not get connected with this bevel gear which goes to throw the screw upon the sector. That was for the purpose of enabling him to do that. Then upon the end of this shaft there was an apparatus to turn this by hand.

4 Q. For what purpose did he turn it by hand?

A. I suppose to set it where he had a mind to—to change the position of the cam here in relation to the valve.

5 Q. So as to regulate by hand, if necessary.

A. I do not know about the regulating. I think it was put there to put the engine in such a position as the engineer should choose before starting her off on work.

6 Q. Is the governor in that description or drawing repre-
224 sented with more than one sleeve, or a sort of a double sleeve?

A. Only one sleeve. The other was a sleeve, to be sure, but not connected with the governor—only in an indirect way. I think it amounted to the same thing exactly in its working connection that it does here.

7 Q. I wish to get what is described before the court, as near as possible. The sleeve of the governor there, as I understand it, is that part which, when the balls rise, carries up the cog-wheel?

A. Yes.

8 Q. When these governor balls are free to move up and down in that machine, within the range, is there any regulation effected at all?

A. There is none, with this explanation: whenever the range is not within the engagement of the gear. If the gear does not engage, there is no regulation.

9 Q. Within the range the governor is free to act without being stopped by these cog-wheels—there is no regulation at all?

A. None, until the gear takes effect.

10 Q. Then we will suppose that cam is to be pushed forward, so as to be cut off short. Does the position of the balls, as they rise, indicate by their rise how far the cam shall go forward?

A. Not at all.

11 Q. Explain to the court, and operate the model, showing how regulation by the movement of the cam was effected?

A. The regulation is by the movement of the engine, and not by the change of position of the governor. This mill regulation is connected with the engine the same as in the water-wheel it is connected with the water-wheel; and the movement of this cam, to change the cut-off, is by the movement of the engine, and not by the change of the governor. The change of the governor goes to break the connection, as the case may be, or change it from one direction to the other, but does not carry with it the cam.

12 Q. That is, the rise or fall of the governor balls places no stop, cam, or other instrument in a position indicating the point of cut off.

225 A. Not at all.

13 Q. Now, suppose the cut-off has to reduce the speed by cutting off from $\frac{3}{4}$ stroke down to $\frac{1}{4}$, and you wish to give a corresponding change to that cam with reference to the valve to do that?

A. Yes.

14 Q. In order to do that these balls, rising to indicate that the engine is going too fast, take hold of that and show how the cam is pulled along?

A. The amount of this change here has no other effect than to put the parts in motion which go to make the change. They do not make the change *per se.*

15 Q. State to the court—suppose you want to change that from cutting off at $\frac{1}{4}$ to $\frac{3}{4}$—what, in point of time, is the operation of the machine.

A. That depends on the rate at which it is geared. The engine must run a sufficient number of turns to screw *this* [the cam] to where you want.

16 Q. What is sufficient gear?

A. I do not know. I know there is only one rate of change, and that depends on the rate of motion of the engine. To regulate well, in my judgment, the rate of movement must be proportioned to the rate of change; that is, the parts which go to change the cut-off must be always in positive relation to the balls of the governor, so that their position shall depend upon the position of the balls of the governor. That is not the case in this. (French.)

17 Q. You say the engine must make a sufficient number of revolutions to wheel along, by means of an endless screw and cogs, the cam into the position it is to take, either cutting off long or short.

A. That is the nature of this contrivance.

18 Q. And how many times of the fly-wheel will be required to change it from $\frac{1}{4}$ to $\frac{1}{2}$ or $\frac{3}{4}$ you do not know?

A. That would depend on the rate at which this was geared.

19 Q. Is that, in your judgment, an engine that regulates rapidly in setting the steam to the requirements of the work to be done?

A. It would regulate rapidly if you make the gear to regulate rapidly.

226 20 Q. What is the effect of that?

A. It would regulate sometimes more rapidly than you want. Whenever a change took place it would make the same regulation for a small change as it would for a great one. That is the difficulty. The rate of change is proportioned to the rate of motion of the machine, and if it is geared so as to reduce small imperfections it would take too long to make large changes.

21 Q. (By Mr. Curtis.) The change which is made begins when the screw is set in motion?

A. Yes, sir.

22 Q. Suppose a large change was wanted, could it work any faster than to make a small one?

A. No, sir; the change is in proportion to the speed of the engine—not in proportion to the change.

23 Q. Take a rolling mill, where great changes are necessary, and you throw off a large quantity of work—would this work faster to make a great change than to make a small one?

A. Not at all.

By Mr. Stoughton:

24 Q. Then it will take three times as long to change from $\frac{1}{4}$ to full stroke as to change from $\frac{1}{4}$ to $\frac{1}{2}$ stroke?

A. Yes, sir.

25 Q. So that your excess of power is going on all the time until you reach the point of cut-off?

A. Yes, sir.

26 Q. Do you regard the yoke there as the stop or gauge bar in the defendant's machine?

A. I do not.

27 Q. I understand you to say, during the time the sleeve is free to move, there is no regulation going on in the engine?

A. No, sir.

28 Q. Is there any regulation in the defendant's machine or the plaintiff's except while the balls are free to move up and down?

A. No, sir.

227 29 Q. Is not the range of regulation in the defendant's and in the plaintiff's confined to the range of movement of the governor sleeve?

A. Yes.

30 Q. Is there any regulation affected in either the plaintiff's or the defendant's after the balls of the governor get up to the fixed point.

A. There is no change—no regulation.

31 Q. Are the defendant's and the plaintiff's alike in these respects?

A. Yes, they are.

32. Q. Are they unlike or like *this* [the French engine] in these respects?

A. Unlike *this.*

33 Q. Now, in reference to the sleeve of the governor in the defendant's and the plaintiff's carrying what has been called sometimes the third instrument, but what I call either the stop or the gauge bar, for the purpose of determining the point at which the valve gear shall disengage and let the valve go, are they like, in that respect, the defendant's and the plaintiff's?

Mr. Keller: I believe that that was in the opening, also.

Mr. Stoughton: Then I will not press it.

34 Q. Did you ever see a machine constructed on that plan [the French engine] for regulation?

A. I have seen this plan used for the regulation of water-wheels, but never upon steam-engines, and this, without modification, is not much used now. It is not used anywhere where considerable regulation and accuracy of regulation is required even upon water-wheels. This has been superseded by a patent which has run out, so that, as the changes are greater or less, it could regulate faster or slower. This is objectionable even for that.

35 Q. Look at what has been specified, I think, as the Field and Maudsley engine, (No. 5.) I observe here, Mr. Waters, that the sleeve of the governor is attached directly to the cam that opens the valve.

A. Yes.

228 36 Q. What valve do you understand that cam to operate?

A. The throttle valve, or a cut-off in the place of the throttle valve.

37 Q. Placed in a steam pipe?

A. In a steam pipe or steam chest backside of the steam valves.

38 Q. Now, sir, do you understand that governor which thus carries that cam which opens the valve to be connected for the purpose of regulation in the manner that you find in the plaintiff's or the defendant's?

A. No.

39 Q. State the difference between the two, and the difference in the operation of the two.

A. The great difference is that it works only the cut-off valve and not the steam valve. There must be two steam valves to work both ends of the cylinder; and in order to regulate with economy by the cut-off the connection must be upon both steam valves, because in working by the cut-off, when this cut-off is opened, you do not get the full pressure of the steam upon the piston until sufficient steam is received from the boiler to fill the space between this cut-off and the piston with steam at the pressure in the boiler. The direct operation of which is, that power is lost because it would not have a bearing upon the piston, and that it rushes through and does not press upon the piston. It will begin to press a little upon the piston, and it will not produce its full effect until it goes with the same pressure as it is in the boiler.

40 Q. Do you find connected with the sleeve of that governor any stop or cam to determine the time when the valve gear shall separate, or does it carry a part of the valve gear itself?

A. It carries the cam the same as it would if this was hitched on *here*.

41 Q. Then, do you find here any combination of the governor with the stop for the purpose of detaching or liberating the valve gear?

A. I do not understand that [the Field valve gear] to be detachable valve gear. It is a pretty close margin to say it does not liberate the valve.

229 42 Q. I am not asking you about that. I want to know whether you find attached to the sleeve of that governor any third instrument to determine the time when the valve gear shall be liberated or detached?

A. It is hung to the cam itself. The cam is on the sleeve of the governor, and the cam determines the time at which it shall be cut off.

43 Q. Exactly as though hung to this *here*? [The French engine.]

A. Yes.

44 Q. Do you find in the defendant's or in the plaintiff's any part of the valve gear hung to the slide of the governor, or do you find the stop, which is to be placed in position and come in contact with the valve, hung to it?

A. There is no part of the valve gear hung to the governor on the defendant's or in the plaintiff's.

45 Q. (Judge Curtis.) I understand you to say that the cam itself is attached to the governor, and is it to be moved by the power of the governor?

A. Yes, sir; the cam there opens that valve.

46 Q. What effect has it upon the governor that it has the duty of carrying that valve with the valve gear riding upon it?

A. It makes it work badly, and it would work worse if it had two valves instead of one.

47 Q. The court: Do you mean that in that arrangement of the Tredgold, it is the power of the governor that operates to raise the valve?

A. No, sir; the power of the governor operates to move the cam in position, and the cam is the power that raises the valve.

48 Q. What moves the cam?

A. The governor.

49 Q. Then the power of the governor raises the valve?

A. No, sir; the regulator moves the cam up and down, and the power of the engine turns it around, and it opens the port with the power of the engine as the opening power. I understand, sir, that the power does not come through the governor. It comes through the shaft of the governor. *This* shaft carries the governor. The governor raises this up and down. The governor changes the position of the cam. The power of the governor is a balance of

230 power, and it is not available for any large amount of action. The engine would have to depart a long way from its regular course of running before it drags this after it.

50. The court: It is the force applied by the cam on the slide of the governor which opens the valves?

A. Yes, it is the force applied by the cam upon the slide of the governor, but applied to the rotary motion which comes from the engine, and being embarrassed with this pressure it moves with great difficulty. Now, when there are two cams this difficulty is increased, not only from the fact that there are two instead of one, but that the time that they are in contact is twice as long.

51 Q. Therefore you think it important to get rid of that connexion.

A. It is so important, I think, that you cannot work well without getting rid of it in a machine of considerable size.

52 Q. Will you look at the modifications of valve gear shown in this model? [Defendant's plaintiff's model No. 2.] It is said of the spring bar which holds the valve in that modification of gear that the extent of hold that these shoulders take for the purpose of opening the valve is not determined by the stops or gauge bars. Now, suppose you make these shoulders deeper *there*, thus changing the form of the spring bars, will their hold upon the valve gear be determined at the time they take hold upon the arm?

A. Certainly; in that model the faces of the connecting hooks and rocking levers are very short. They are blocked off so that they cannot go up as far as they would go towards the gauge bars or stops; they cannot go up as far as they would go, and therefore they do not come up right against them. They are determined in their position by the depth of the notch. Now, if that is cut deep enough they will go up against the gauge bars.

53 Q. Would that make a different gear of it?

A. No.

54 Q. What would be the effect of making the shoulder deeper?

A. It would embarrass the governor for a greater length of time.

231 55 Q. The governor would be embarrassed during the whole time that the valve is being pulled open?

A. Yes; the cut-off would be just the same, the conditions being the same.

56 Q. Now, it is said that in the defendant's engine the extent of which the tappets shall engage upon the valve levers is determined at the very moment of engagement by the valve bar?

A. Yes.

57 Q. And then the objection is, as you have heard, that the governor will be pinned all the time of the contact between the shoulders and the tappets; will this be equally good with that machine?

A. Yes.

58 Q. Do you think that makes a substantial difference between the two machines?

A. No, I do not. I think it would be worse if it were more delicate, for it embarrasses the governor longer.

58½ Q. It has been said that the defendant's valve gear will always disengage, whether you use the gauge bar of the governor or not?

A. It will, as I have seen it used.

59 Q. What means are used to prevent the tappets rising up above a certain distance?

A. I do not know.

60 Q. If, instead of putting a pin in to prevent that tappet rising up, you stick a pin in to prevent the spring bar rising up, will the plaintiff's always disengage, whether you use the gauge bar or not?

A. The difference is that it will not disengage while it works upon that pin.

61 Q. Do you understand that these machines are made with a view to be regulated by the governor for practical operations?

A. Yes.

62 Q. For the purpose of regulation do those pins make any difference?

A. Not the slightest.

63 Q. You heard the testimony of Mr. Allen this morning did you not?

A. Yes, I believe I did.

232 64 Q. You heard the modifications described by him that he says he put into his engine?

A. I think I understood what he said was done.

65 Q. Do you understand that to be like the plaintiff's or defendant's?

A. I do not.

66 Q. Substanially like?

A. No, substantially different.

67 Q. Why?

A. Because it will not regulate in the right way. One modification in which he said they used it would be like *this*, with this screw apparatus attached here to this cam [French machine.] The other modification amounted in substance to what *this* amounts, [No. 5,] with a rather worse arrangement. In the one place this change takes place by the action of the machine, the same as in this French machine, and in the other by the action of the governor as in the Tredgold machine.

68 Q. By one valve?

A. Yes, always upon the same valve, the steam valves working between that and the cylinder, the same as *this*, [the Tredgold machine;] that is, the governor operated a moving cam that moved the valve in one mode; and in the other, the power of the engine, the same as in this.

69 Q. In reference to this dash-pot and air cushion, are you acquainted with the form of dash-pot described by Mr. Sickles?

A. Yes.

70 Q. Are you acquainted with it as used in practical operation?

A. I cannot say very much about how it is used in practical operation. I understand it is used by making a jet by the form of a piston, and his patent was for making a jet through holes in the piston. I

had some acquaintance with it at one time and I think I understand the operation.

71 Q. Is that dash-pot of Sickles properly constructed or arranged for using air instead of water, as described by him, or as you know of its having been practically used?

A. No; I understand that the fall of the valve in the Sickels dash-pot was broken by a jet of water, by generating a jet of water, the orifice becoming constantly less until it was closed. In this
233 air vessel I understand it to be an air cushion. After the piston passes the orifice, the air is enclosed, and it is not the jet that is relied on, but the elasticity of the air.

72 Q. What is the difference in practical operation between a dash-pot filled with water and the air cushion?

A. The difference is that by the air cushion of Corliss, as embodied there, and as I believe is described in his patent, I understand to be the moving of a plunger in a cylinder, never coming out of the cylinder, of uniform size in its bore, and then a hole in that cylinder having such a relation to the plunger and the valve apparatus that about the time the plunger has passed the hole through which air is passing out, the port should be covered by the valve, and the elasticity of the air being caught up and confined so tight that there is no escape, the elasticity of this air is taken to stop the valve when it is moving to overlap the port.

73 Q. The air escapes freely until the valve is to be closed?

A. Yes, escapes freely.

74 Q. When the valve passes the hole, the air is confined?

A. Yes, it operates to break the fall of the valve in such a cylinder.

75 Q. Then to make it like Sickels' you would have to put a water reservoir round it with water in it?

A. Yes, we would have to break the fall by the jet of water. It would be the same as Sickels' then.

76 Q. Do you think it would be using it in the same way?

A. It is substantially for the same purpose, but not for the same thing in the same way. I should say broadly that they were for the same purpose, but substantially different.

77 Q. You have heard the description of this check-ring valve which was said to have been combined with the liberating valve gear; was the check-ring valve, as you understand, the same kind of valve as that combined by Mr. Corliss in his valve gear?

A. No.

78 Q. Wherein did it differ?

234 A. It did not move parallel to its seat; its seat was at an angle with the motion.

79 Q. Was there any other difference between the check-ring valve, as used, and the slide valve?

A. That would depend upon the length of the check rings, and some other things. One of these things runs into another without much space between the two—the one begins where the other drops off. If there was no crown upon that valve, and if it worked in a

pipe, having an orifice cut through, so that it moved over and back as the flat valves do, it would be such a valve as that.

80 Q. Had they a crown?

A. They had.

81 Q. What for?

A. To make them tight when down. When they had reached the crown they had reached their seat. I suppose they came upon that and sat there. The slide valve does not come to rest upon the valve, but upon the valve gear. It is always upon its seat I might say.

82 Q. Will you state whether you know of any way of using the steam-engine for practical purposes, in which it is more economical to throttle the steam by a valve before you permit it to enter a cylinder to do its work, than to let it have full boiler pressure?

A. I do not.

83 Q. Now, with reference to the old eccentric hook which has been spoken of as being an 100 years old, are you acquainted with that, and its application to valve levers?

A. Yes.

84 Q. Will you look at that spring bar, in combination with the valve lever, and state whether that is like the combination of the eccentric hook with the valve levers; and if not, why not?

A. For the reason that the valve lever is not made to work and detach as that does.

Cross-examined by Mr. Dickerson.

1 x Q. You have said that you were familiar with the descriptions and drawings of this French machine?

A. Yes. I am not very crisp in my French; I do not
235 pretend to be. I have worked at this description and drawings till I know what the machine is.

2 x Q. Take this part of it—these four lines. You understand what the author states there in respect to this governor?

A. I will not undertake to read this intelligibly.

3 x Q. The author there suggests that this governor, and as he describes it, may move too rapidly, and that another plan, which he suggests there, would be perhaps better, because it regulates more slowly.

A. I do not understand what the other plan is. Tell me.

4 x Q. He suggests it will be more convenient, better probably, to have a governor that will regulate more slowly than this does. You think he was mistaken about this?

A. Yes.

5 x Q. You think it would be better to have one to regulate more rapidly?

A. I think it is better to have one just according to the change you want—either rapidly or slowly, as you want. The difficulty with this is that it is not changeable; it has to regulate always at the same rate. If you make it to regulate rapidly, it will regulate faster than you want it; if you want to regulate slowly, you would be too

long a time about it. The rate of regulation should vary with the rate of change that you require.

6 x Q. You have read this description of the plaintiff's patent, I believe?

A. I have read it enough to know what his description is.

7 x Q. In your opinion, supposing you should put a mill governor upon the Corliss engine, in place of the fly-ball governor, would it not be substantially the same machine as he claims in his patent?

A. What do you mean by the mill governor?

8 x Q I mean a machine composed of two fly-balls with two gears. *There* it is. [Pointing to it on the French model.]

A. I consider it a misnomer. *This* is a fly-ball governor just as much as *that* is down to *there*. *This* is a mill regulation. *That* is my nomenclature.

9 x Q. Is not any mill governor down to a certain point the same as the fly-ball governor?

236 A. No, sir.

10 x Q. I mean the ordinary mill governor?

A. I have not seen such a one as this.

11 x Q. I mean such a one used in a cotton mill?

A. I have not seen such a one as this in a cotton mill lately.

12 x Q. I will ask you whether the mill governor, such as you have seen working in a cotton mill, did not have, in the first place, a pair of fly-balls?

A. I think I never saw one without.

13 x Q. Then they had a pair of cog-wheels that ran upon the same spindle?

A. Yes.

14 x Q. Have you ever seen a mill governor with three cogs, together with a fly-ball governor?

A. That is the one I have seen—and then a clutch between them.

15 x Q. Tell this court whether, in your judgment, if you should put that machine upon the Corliss valve gear, it would or not be within the description of the patent.

A. I am perfectly clear it would not.

16 x Q. In that description I find Mr. Corliss to say: "And my invention consists in effecting this object by a new mode of operation, which is embodied in a combination of two sets of apparatus, one of which I call the regulator, and the other a liberating valve gear. The former is an instrument which, when set in motion, changes the relative position of some of its parts, as changes occur in its velocity, and by virtue of such changes is capable of communicating motion to other mechanism."

A. No, sir. This does not communicate motion to the mechanism. It puts the parts in that mechanism in action.

17 x Q. You say that the power is taken from the engine in this one?

A. Yes; and it is not in the other one. The power moves them up and down.

18 x Q. Is not the power that moves the common fly-ball governor

taken from the engine, and is it not a loss of just so much power from the engine's work?

237 A. Yes.

19 x Q. Whatever power is required to move the cam, or stop, or valve, whatever it may be, whether it be communicated through the fly-balls or communicated through the gearing, is just so much power taken from the engine?

A. Yes; I think there is not much doubt about that.

20 x Q. Then in the two cases the power to do that is taken directly from the engine?

A. Yes, I agree to that; but I do not agree to much else.

21 x Q. They are both known forms of governors?

A. *This* is just like *that*, [plaintiff's machine.]

22 x Q. Which is just like *that*?

A. *This* governor.

23 x Q. Like what?

A. On the French.

24 x Q. Is not *this* what is called a governor—the whole together?

A. Not by me.

25 x Q. Is it not known so in machinery?

A. I do not want to answer in your language, and have it construed according to mine. I understand the governor to end with *this* part of it *here*, [the sleeve.] Now, what is connected with that sleeve in the one case and in another may be very different, without varying the character of the governor itself. It is the mode of regulation that is changed.

26 x Q. Supposing you take out this gearing, will that do anything to this machine?

A. No.

27 x Q. Then it will not be a governor then?

A. No.

28 x Q. Then you have to do something else before it is a governor?

A. If you will make *these* parts as they ought to be, it will be a good governor.

29 x Q. Has it not fly-balls.

A. Yes; it is a governor with fly-balls.

30 x Q. You have heard the testimony that this is a machine put in a water cylinder. Did they put it in a water cylinder so

238 as to hold it fast, so that it could not go more than so fast? Does that make it any less a fly-ball governor than before?

A. Of course not.

31 x Q. Is it not a part of the mechanism necessary for regulation?

A. I do not know; it may be better for it.

32 x Q. Is it a part of the governor or not?

A. It is no part of the governor.

33 x Q. Does it not affect the speed and regulation of the engine?

A. I suppose it does.

34 x Q. It is a machine which affects the speed and regulation, but is no part of the governor? Is it or not a part of the governor?

A. It may be, but I think not.

35 x Q. This is a machine that has an appendage to it to make it go slower?

A. I do not understand it so. I do not choose to run these together in that indiscriminate way. I like to speak of them according to their office.

36 x Q. You have attempted to draw a distinction between these two governors?

A. I have not, but you have. I have attempted to draw a distinction between these two modes of regulation.

37 x Q. Will you point out to me in the patent what part of the description or claim confines this patent to the fly-ball governor?

A. Certainly; it does not confine it to a fly-ball governor. He confines it to any kind of governor.

38 x Q. Is *this* any kind of governor?

A. This is a fly-ball governor with a mill regulation.

39 x Q. Then your distinction is that a part of this machine only is a governor, and the rest is not?

A. I think I have told you what is a governor pretty generally.

40 x Q. Is that your distinction that that is part a governor and part not?

A. What do you mean?

41 x Q. Supposing these fly-balls open and shut the valves
239 of the cylinder with water or steam in so that it will go on one way or the other as the valves move higher or lower.

A. Show me a machine. I do not like to speak distinctly as to that. My opinion is that it is within Corliss' invention.

42 x Q. That is a machine in which the fly-balls move by steam?

A. But the position of the fly-balls indicates the rate of change.

43 x Q. When the fly-balls open they let in the steam?

A. They let in more steam when it moves a good ways than a little ways. It moves quicker when a greater change is required than when a smaller one is. It certainly is not like *this*, [the French engine.]

44 x Q. Is this machine a governor or not?

A. I do not think it is. I think *this* is a mode of regulation.

45 x Q. Now, you have spoken of this Tredgold machine: do you mean to say that that cut-off works there in place of the throttle?

A. Yes.

46 x Q. Do you not know that in the description of that machine that there is a throttle valve also placed—an application to the throttle valve as well as to the cut-off, when they desire it?

A. Yes.

47 x Q. And there is a throttle valve?

A. Yes, between the steam valve and the boiler.

48 x Q. And that is true of any slide cut-off valve. Is it not outside of the ordinary main slide cut-off valve?

A. Yes, only sometimes it is made to act as a cut-off valve.

49 x Q. Take the Tuffts engine; that has one on the back of the main slide. Is that a throttle valve cut-off?

A. I did not say it was. I said it was in the place of a throttle valve. So is Tufts', although he gave little consequence to it.

50 x Q. You said that that machine of Tredgold's would not regulate with as much economy as if the valves were up to the parts of the cylinder?

A. Yes.

240 51 x Q. Whether regulated or not, it would not alter the fact of economy?

A. It would, because we are talking of the regulation of the steam-engines using expansive force; these two have regulation of that character, and must work in that way.

52 x Q. *That* is an engine that cuts off behind the main slide?

A. Yes.

53 x Q. You say that is not so economical as if it cut off behind the main slide?

A. Yes; if you regulate at the backside of that throttle valve you waste more steam.

54 x Q. You were asked a question, whether you knew of any engine in which economy would not be greater in working the governor to the cut-off than working it to the throttle valve; have you ever made any calculation upon those cases that have been proved here in court, in the case of Mr. Stearns and another gentleman, who were witnesses?

A. No, sir.

55 x Q. Have you ever calculated to know the difference of economy between an engine running with a throttle valve and the fixed cut-off, and that running with a variable cut-off?

A. No; only in a rough way.

56 x Q. Do you think that you are sufficiently acquainted with the law of steam to answer?

A. I think I understand this proposition. It is this: Under the same circumstances, letting the relations of the two cases be the same, the same cylinder, the same quantity of steam, &c., whether you cannot get more power by using a throttle valve than a cut-off, I say you never can do it.

57 x Q. We had this engine of Mr. Stearns' testified to here.

Mr. Waters: I do not want to go into that.

58 x Q. On this Tredgold governor does not that cam operate in the same way that it does on the French engine?

241 A. It does.

59 x Q. Whatever the governor has to do in the one it has to do in the other?

A. No, sir; in this [the French engine] it has nothing to do but to put the parts in action to move the cam, while *there* [the Tredgold engine] it has to move the cam.

60 x Q. I refer you to the patent in suit 763, folio 110?

Witness: I was going to say one thing in regard to this patent; if I understand it right, and I have not read it very particularly, my impression is, that that patent excludes this [French engine] from being of the nature of Mr. Corliss' invention.

61 x Q. At folio 110 he refers to the French engine particularly: "—— but all these plans, under various arrangements of mechanism, embody a common method of operation, the same substantially as that in the engine referred to in Tredgold's Treatise."

You have seen one of those drawings which have been in evidence here, where there is a little roller; is that the same mode of operation?

A. Substantially it is; that roller will make the wire drawing greater than without a roller.

62 x Q. In this case is not *this* cam free to act one-third of the stroke?

A. I believe it is.

63 x Q. Is not *this* governor free to act on two-thirds of the stroke?

A. Yes.

64 x Q. Is it not in Green's engine?

A. Yes.

65 x Q. Is it not in the French engine?

A. No.

66 x Q. Is it free to be governed, more or less, by the point being cut off?

A. Yes.

67 x Q. You referred to those things called sliding bars, shoulders, and hooks, upon that engine, and you undertake to make
242 a comparison between that and the eccentric hook. Considered with reference to the object of the opening and closing of the valves, not for the purpose of being cut off, but for the purpose of opening and closing the valves, is not that combination of that rocking arm with that bar the same substantially as the combination of the common eccentric rod with the rock-shaft arm upon which it rides?

A. For the mere purpose of opening and closing the valve, when it does not detach, it is the same. It is the character of the engine to do so. There is a provision that if the valve should stick upon its seat it would be sent home by the sliding piece. It is not made to work so.

68 x Q. I am speaking of it now in reference to the first claim of that patent for the two things.

A. I cannot say.

59 x Q. Do you mean to say here that the Sickels air dash-pot and the Corliss dash-pot, the one working upon air and the other working upon water, according to the Sickels plan, are not substantially the same thing?

A. I said that they were not substantially the same thing; but I do mean to say that the air cushion dash-pot of Corliss, in its mode of operation, when connected with that slide valve, is substantially different from Sickels', although Sickels having a patent for that combination, I think it would be an infringement of Sickels' invention, he being the first to use it. I think that the air cushion is different, because there is no necessity for any stuffing box or any guide in connection with it for the purpose of acting as it does. It is

simply a plunger going up and down in a cylinder that fits it all the way, not like Sickels'. Then it breaks the fall by the elasticity of the fluid and not by the jet of the fluid.

70 x Q. Now, upon that question of jet. It is an air dash-pot with an escape hole upon one side, and as the plunger descends it covers that aperture and the air is driven out?

A. At the same time it is compressed.

71 x Q. And so is water also?

A. For all practical purposes it is not compressible.

72 x Q. But retardation begins the moment the spurt begins.

243 A. I think retardation begins before the spurt begins; I guess it is about the same time.

73 x Q. Does not the resistance begin from the beginning of the descent?

A. Yes.

74 x Q. And it does in air?

A. Yes, the fall is not broken in that way. The supply in the dash-pot above fills the cup and furnishes to its wants. The great feature is to break the fall by the jet out of the cup, and within as short limits as possible, so as not to wire-draw the steam.

75 x Q. Take the air dash-pot $\frac{1}{4}$ of an inch deep below the hole, and the plunger comes down and resistance begins. Does resistance begin at the time it begins to close the orifice, or before?

A. Not necessarily. That depends upon the size of it when you use air, and the size of the piston and the rate of fall.

76 x Q. When it comes to closing the aperture, and it has got $\frac{1}{4}$ of an inch to go, how far can that plunger descend without resistance?

A. With the air it would go right down past the hole.

77 x Q. Then it has to stop within $\frac{1}{4}$ of an inch?

A. A part of it.

78 x Q. And stops, because two bodies cannot occupy the same space at the same time?

The court: We will not go into that. He has stated the fact.

EDWARD S. RENWICK recalled.

Examined by Mr. Stoughton:

1 Q. Are you acquainted with the description and drawings of the French machine?

A. I am, sir.

2 Q. Look at the model there and state whether it substantially represents the description and drawings.

A. It is a substantial representation of certain parts taken from the description and drawings.

244 3 Q. Do you find certain parts in the drawing left out in the model?

A. I do, sir.

4 Q. Now, sir, do you find, viewed as a means of regulation in the same machine, substantially the same, or substantially a different mode adopted from what you find in Corliss'?

A. I find a substantially different mode.

5 Q. State, briefly, why.

A. In Mr. Corliss' arrangement the extent to which a change is made in the cut-off depends on the extent or distance to which the slide of the governor is moved, and is directly proportionate to that movement. In the French machine the extent to which the cut-off is varied depends upon the length of time during which the mechanism is operated. The one depends upon time, bearing a certain relation to time, and the other depends upon the movement or distance travelled.

6 Q. Do you find in *that* [the French engine] any stop or cam, carried by the slide of the governor, for the purpose of determining the time when liberation shall take place?

A. I do not, sir.

7 Q. Now, Mr. Renwick, you have heard some statements here which I may as well at once dispose of, in reference to the use of a water pot in which the extension of the governor's sleeve works below the governor in some of Mr. Corliss' engines?

A. I have.

8 Q. Have you ever seen that in operation?

A. I have, sir.

9 Q. Have you ever seen them working without it?

A. I do not recollect whether I have or not. I think I have. My impression is that I have.

10 Q. I want to know whether the effect of using that under the governor in the defendant's machine, and for the same purpose, would be the same either used in the defendant's or the plaintiff's machine?

A. It would be precisely the same.

11 Q. What is the purpose of using that water pot or cylinder?

A. As I understand it, the purpose is to prevent a tremulous
245 movement in the governor; or, in other words, to steady it in changing its position.

12 Q. How does it work in that pot? Does it work close or loose?

A. It works loose. There is a disc attached to the rod, and turning with the rod; and this disc does not touch the pot. There is a space all round; and there is water placed in the pot, and the raising or lowering of the disc, by causing the passage of the water from one side to the other, steadies the movement.

13 Q. Does it prevent the movement due to the fly of the balls, or is it to steady the tremulousness?

A. It steadies it, but does not prevent it.

14 Q. Does it interfere with the active movement of the balls up and down?

A. Well, in one sense it does interfere, because it prevents it from moving with this tremulousness or tetering motion as it ascends or descends.

15 Q. Now, Mr. Renwick, I will ask you if you change the size of the governor, and run into a different speed, whether that would have the same effect?

A. I think it would. I think if you ran a smaller governor at a higher speed you would not have so much of this tremulous movement.

16 Q. Have you had your attention called to this valve gear in the course of the trial?

A. Yes.

17 Q. Will you show to the court how, by simply preventing the upward rise of the spring bar, it would cut off always without the use of the gauge attached to the governor, precisely as the defendant's tappets do? [Models C and D.]

A. In the defendant's machine, if we examine it, we find underneath the slide bar a pin passed through the tappet. That pin prevents the tappet from being run up beyond a certain distance by the operation of the spring.

18 Q. Suppose that that tappet was permitted to fly up, and was not checked by that pin?

A. Then, if the gauge bar was out of the way, so that the tappet was not controlled by the gauge bar, the tappet would hold on
246 longer to the arm. It would not cut off at the end of the stroke. The arm would hang on to the tappet as the tappet went backward after going to the end of its stroke.

19 Q. Suppose the tappet [defendant's engine] to be allowed to come up high enough to hold on to the end of the stroke, would there be any practical difficulty in working the engine with the parts in that position with reference to each other, by adjusting before starting the lap and lead, and altering the eccentric?

A. No, sir. The eccentric in this model is not set for such a mode of operation. It is set here to cut off at $\frac{5}{8}$ stroke or $\frac{3}{4}$ stroke, and in the other case it would not cut off beyond half stroke—that is, if the eccentric were so set that the detachment or separation of the parts need not take place for the working of the engine, it would not cut off beyond half stroke.

20 Q. Will you be kind enough now to show the gauge bar and the spring bar [plaintiff's model C] so arranged that there will be no cut-off by the gauge bar?

A. Suppose the gauge bar now to be set to make no disengagement. [Illustrating.] As I stated before, in the defendant's engine there is a pin which prevents the upward movement of the tappet when the gauge bar is taken out of the way. Now, place such a pin above the spring bar of the model of Corliss, [model C,] a pin which corresponds with that in the defendant's model, so that it prevents the shoulder from rising up so far, why, then, the liberation will take place, or a separation of the parts will take place, even though the gauge bar be taken out of the way.

21 Q. In making that change, do you think it changes the gear substantially?

A. I do not.

22 Q. Again: turn your attention for a moment to the shoulders that you see upon *these* spring bars *there* in the model, and state whether, at the time those spring bars engage for the purpose of opening the valves the extent to which the shoulders shall take hold,

the depth of engagement is determined by the gauge bar of the governor; and if not, tell the court how it shall be gauged by the governor.

A. As *this* model [No. 2] is at present constructed, the shoulder
247 is so shallow that what may be called the neck of the rod strikes the pin upon which the shoulder engages before the body of the rod comes in contact with the stop or gauge bar, and therefore that neck there prevents the slide bar from moving sufficiently towards the gauge bar to come into contact with it. If, however, the shoulder was made deeper, or, in other words, the neck cut more away, the spring would move the slide bar further towards the rock shaft; and if this shoulder was made deep enough by such cutting away, the spring would move the slide bar far enough to let the face of the slide bar come in contact with the gange bar at the time that the shoulder came into contact with the rocking arm. That can be better shown upon the model of Mr. Corliss [plaintiff's model C.] In the condition that that model now is, with a deep shoulder on the slide bar, the body of the slide bar always comes in contact with the stop prior to the engagement of the shoulder of the bar with the toe of the rocking arm, and the gauge bar limits the depth of that engagement. Now, if we leave all the parts the same, and fill up the rod so as to make the shoulder shallow, why, then, the end of the toe coming in contact with that filling will prevent the shoulder of the slide bar from taking such a deep hold upon the toe of the rocking arm; and the consequence will be, that at the time of the engagement of the slide bar with the toe of the rocking arm, the body of the slide bar will not come in contact with the gauge bar. In the present model [Corliss' C.] I can produce that effect by placing a pin in a hole in the shoulder of the slide bar so as to make it shallower. Then, at the time the shoulder of the bar engages with the toe of the rocking arm the body of the slide bar does not come in contact with the gauge bar, and that change in the depth of the shoulder makes no difference in the period at which the two separate, because they will separate at exactly the same position of the crank of the engine. Your honor will notice the position of the crank of the engine now. I will pull out that pin, [illustrating,] leaving the gauge bar as it was, and you will see the same crank precisely in the same position at the time of separation.

23 Q. If I understand you, when you cut the shoulder deeper, in the case that you have supposed, as you have done it here,
248 then the bar, upon which the shoulder is, is impinged against the stop?

A. Yes.

24 Q. It impinges at the moment of engagement?

A. Yes, before an engagement. It is a little previous to engagement, but it is always impinged at the time of engagement.

25 Q. And continues impinging during all of the time of the valve being opened?

A. Yes.

26 Q. In that case it is riding upon the governor?

A. Yes.

27 Q. When the defendant's tappets ride upon the gauge bars?

A. Yes.

28 Q. Mr. Curtis: In this connection I would like to ask the witness a few questions about that passage in the specification which has been so much criticized upon the other side. It is line 41 in patent 780.

"The blocks (u u) for the two valves are secured to a sliding rod. (y,) and the latter may be connected with the governor at (r,) to determine by the velocity of the engine the position of the gauge bar, and hence determine the distance to which the shoulders on the spring bars may be forced outward by the springs which will determine the period of the closing of the valves."

Now, I wish to inquire whether, if you deepen the notch in the manner stated, that it is not literally true throughout the whole period of the opening of the valves?

A. If you deepen the notch, it is so throughout the whole period of opening the valves.

29 Q. Suppose you do not deepen it, but that it is as shown here by that model, then it is not true in reference to the period of disengagement?

A. Yes, it is true in reference to the period of disengagement. And the greater or less time during which that limitation will
249 occur will depend on the greater or less depth of that shoulder up to the point when it will always hang.

30 Q. It may be so deep that the depth of engagement is determined at the time of engagement, or so shallow that it is only determined at the moment of disengagement, and anywhere between the two?

A. Yes. sir; depending upon the depth of the shoulder.

31 Q. [By Mr. Dickerson.] And the governor will be free to act?

A. Yes.

32 Q. It is said that the governor in the defendant's is pinned during the opening of the valve. Is it pinned so that it cannot rise up?

A. No. The gauge bar has nothing to prevent its rising, whatever it may have to prevent its descending. It can rise and leave the tappets when the tappets are engaged.

33 Q. Now, in reference to the same relation in the plaintiff's, when the shoulder is so deep that the gauge bar connected with the governor is always impinging there upon the rod. Are they pinned alike in the defendant's?

A. If you make the shoulder of sufficient depth the pinning of the governor will be the same in the plaintiff's as in the defendant's.

34 Q. [By Mr. Curtis.] I ask Mr. Renwick to produce a drawing, showing the line of movement taken by the parts of the valve gear when disengaged, when constructed according to the original description described in the patent of the plaintiff, showing the line of motion when the disengagement takes place, and the line of motion in

the defendant's when the disengagement takes place. I merely ask, Mr. Renwick, if he has made this?

A. Yes.

[Witness produced drawing and explained it to the court.]

35 Q. In connection with this subject let me call your attention to the drawings of Mr. Corliss' patent, representing that modifi-
250 cation of valve gear and spring bar, and let me ask whether the shoulder in the drawing upon that spring bar is represented deeper, and how much deeper in proportion—that on this model?

A. I measured it, and find that taking the length of the rod as a standard the depth in this drawing is three times what it is in that model, [defendant's large Corliss' model No. 2.]

36 Q. [Mr. Stoughton.] Is the description that you got from hearing the testimony of Mr. Allen in court of his apparatus for regulation substantially like that adopted by Mr. Corliss and the defendant?

A. It is substantially unlike it.

37 Q. In what respect is it unlike, as described by Mr. Allen?

A. As I understood Mr. Allen, he described two modifications, or two arrangements, more properly called. In one arrangement the fly-ball governor was applied directly to move the cam which operated the expansion valve, that expansion valve being a valve between the steam chest and the boiler, and operating equally for both steam ports at the ends of the steam cylinder. In the other arrangement that he described there was interposed between the fly-ball governor and the cam a system of gearing and screw, similar in its operation to the gearing and screw of the French machine, so that the power of the engine itself—the movement derived from the movement of the engine itself—changed the position of the cam in the latter case, while the spread and contraction of the governor balls effected the change in the position of the cam in the first instance, and, as I have mentioned, was substantially like what has been called the Tredgold engine. The only difference between the two that I saw was, that Mr. Allen made his cam go round only half as fast, and had to put two projections on his cam, one on each side, while by *this* arrangement, [Tredgold engine,] by making the cam make two revolutions for each one of the engine, there is one revolution for each stroke, and therefore it was only necessary to have one projection on the cam.

38 Q. Are those substantially different or formal matters between Allen and Corliss?

251 A. I consider them substantially different in both instances.

39 Q. Did you hear the testimony of Mr. H. B. Renwick in reference to the combination of the eccentric and valve gear, which he mentioned as being 100 years old? Did you understand the testimony of Mr. Renwick and Mr. Copeland on that point?

A. I did; I think I did, at any rate.

40 Q. Do you regard the arrangement as substantially like or substantially different from that which you see in the model of Corliss' modification of valve gear?

A. I regard it as substantially different.

41 Q. Why?

A. In the first place, Mr. Corliss' arrangement is such an one as admits of a disconnection of the rod from the rocking arm by means of a gauge bar. The old eccentric hook as it exists does not.

42 Q. It is its capacity to be used in that relation?

A. It is.

43 Q. I believe I did not call your attention to the Field model?

A. I do not recollect.

44 Q. State whether the mode of regulation there found is substantially the same or different from that adopted by Mr. Corliss.

A. I consider it substantially different.

45 Q. Why?

A. One leading difference which makes a complete distinction between the two systems is, that in Mr. Corliss' arrangement the regulation is applied to the two steam valves, there being two steam valves, one at each end of the cylinder, both of which are affected by the operation of the governor. In this of Allen's the steam valves are not affected in any manner, but the regulation is applied to the expansion valve intervening between the valve chest of both steam valves and the boiler, the one expansion valve being common to both steam valves.

46 Q. As to the mode of uniting the governor with the cam that moves the valve, is that like the mode of connecting the stop with the governor in Corliss' cut-off machine?

252 A. I think not, and for this reason, that in that engine [Field model] the governor is connected with the mechanism that opens the valves, while in Corliss' it is not connected with that mechanism, but is only connected with an instrument that determines the period at which they close, and which instrument is independent of the mechanism for opening the valves.

Mr. Stoughton inquired if they were to understand that the object of the other side was when they put in evidence the old plug-tree model to contend that it was like Corliss'?

Mr. Keller replied in the negative.

Cross-examined by Mr. Keller.

1 x Q. Do you find it anywhere described in the plaintiff's patent that the stops so called in the reissue, but now the gauge bar, are to determine the extent of latch and catch upon the arm of the valve?

A. I do not find it said in so many words that such is the fact, but I find the description of the engine to be such that that takes place, and I find no description of any other mode than that.

2 x Q. Taking the drawings attached to the patent?

A. I understood you to speak of the patent for regulation.

3 x Q. Do you find it suggested anywhere in the patent of the plaintiff that the stops that are moved by the governor are to be employed or set at any time so as to determine the extent to which the shoulders upon the lifting rod should engage the arms of the valves?

A. I do not find it said that they are to be set for that purpose.

4 x Q. Do you find any description or any mechanism which will do it?

A. I think, so far as I recollect from some measurements that I made some time ago, that when an engine is cutting off at a low period of stroke that such a mode of operation will take place—that is my impression—so that the gauge bar will limit the depth of the engagement.

253 5 x Q. Do you find that that is the intended mode of operation?

A. If it will do it. If I am correct in that idea that the engine will do it when it is cutting off at a short period of the stroke, it must have been the intent to do it.

6 x Q. Is that the intended mode of operation of the plaintiff?

A. When the engine does cut off at a proper period of the stroke.

7 x Q. Answer my question.

A. I prefer to answer it my own way. If I am right in that belief, then there must have been an intent to produce that effect when you are cutting off at short stroke, but there does not seem to be an intent when you are cutting off beyond that period.

8 x Q. What period?

A. When you are cutting off beyond the period at which the gauge bar will limit the extent to which the slide bar will engage with the rocking arm.

9 x Q. At what portion of the stroke will that take place?

A. At a very small portion of the stroke; I do not recollect what.

10 x Q. Upon what drawings did you make that examination?

A. Upon two drawings, and I found that the shoulders upon the one differed a little from the other, and I made the examination upon the deeper shoulders. As I stated, it is so long ago that I cannot recollect precisely.

11 x Q. Would it, in that case, with that engagement, taking the longest one—would it follow 100th part of the stroke?

A. I cannot tell you, for I have no recollection.

12 x Q. The arms of the valve move in a circle in the plaintiff's as well as in the defendant's?

A. It does, sir.

13 x Q. Is it not stated in the plaintiff's original patent that the disengagement is due to the lateral rocking motion that is given to his rod by the wrist plate?

254 A. I recollect there is a statement, but whether it amounts to that I do not recollect. There is a statement in regard to the wrist plate.

Upon the top of page 21 is this statement:

"In order to effect this disengagement of the lifting rods, which communicate the movement of the eccentric to the steam valves, each rod is fitted with an adjustable stop K K against which the face of the rod bears in moving, and which can be moved to cause the hooked extremity of the rod to detach itself from the respective toe of the rock shaft arm when the steam piston has accomplished any required portion of its stroke."

There is one statement of the operation. Then there is a statement on line 52 to this effect:

"The arrangement of the lifting rods, and the method of operating them by the disc plates, as represented in the accompanying drawings, is *particularly suited* to this method of effecting the disengagement of the valves from the mechanism by which they are opened, for the disc plate imparts a transverse motion to the connecting rods which causes them to rock upon the stocks, and thus slide off their respective toes on the rock shaft arms."

As I understand that, it amounts to this: It is a good plan to combine the wrist plate with this movement, because it will assist it.

"But while I prefer this arrangement of eccentric gear, I wish it to be understood that I do not restrict myself to its employment as my improvement, ——"

That is, you may leave out the wrist plate. It may be applied to many other systems by which the valve can be opened.

"——As my improvement may be applied to many other systems of mechanism by which valves are opened. As such systems may not possess the peculiar rocking motion I have mentioned, it will be necessary *in some cases*"—not in all—"to disengage the lifting rods by positive movement."

255 Here is a case: Suppose that model A cam was applied to such an arrangement as in model C, you can disengage by "positive movement, which may at the proper moment be imparted to the lifting rods by some moving member of the engine, through the intervention of any convenient and suitable mechanical device."

14 x Q. I will ask whether there is anything in the specification of Mr. Corliss' original patent which suggests or describes any means by which the curvilinear motion of the rocking arm is to be availed of for the purposes of separation?

A. There is no statement in the case that it was relied upon for separation; but the fact that the patentee suggests that his apparatus is a disengaging apparatus, and may be applied to other systems of valve gear than those containing the wrist plate, suggests to my mind the impression that he intended to apply it to those where a rocking motion was not imparted.

15 x Q. Does he not state, in every case where he provides for the application of other valve gear, that there is some mode of producing this lateral movement of this connecting rod?

A. I do not understand so.

16 x Q. You have pointed out to the court an arrangement [model "C"] that, by the insertion of a pin, you can vary the amount of lap which the hook makes upon the rocking arm of the valve?

A. Yes.

17 x Q. Is there any such description or statement in the plaintiff's patent, either the original or the reissued?

A. Not that I know of.

18 x Q. You pointed out the use of a pin here, which determines, also, the extent to which that hook should rise. Do you find any

such thing named, either in the original or reissued patent of the plaintiff?

A. Not that I know of.

19 x Q. You have stated here that by certain changes in the eccentric of his engines, and an adjustment of the other parts, and a further prolongation of the tappets than appears on the model here?

A. I did not say in such a case as that.

20 x Q. Then take it without the letters patent—with such
256 a change of the eccentric and engine as can be made to work without detaching the valves. I will ask you whether that is the natural condition of the machine?

A. That is not the condition in which it is now set, but there would be no difficulty in setting it in that manner.

21 x Q. Is that the view in which an engineer would venture his reputation in working it?

A. I would as soon take that view as any other; in some respects I would rather, because I can then apply an instrument to insure the closing of the valves under all the circumstances. If the valve mechanism is so set that the rod travels forward and backward equally in the stroke of the engine, so that the valve rod will get back in time enough to close the valve before the next stroke commences, a projection can be applied to the valve rod to bear against the end of the rocking arm and shove it into its place if the weight on the valve should not act. Applying that movement to this engine, [defendant's,] if this slide bar was so set that it could be brought back in time to close the valve previous to the next stroke, an arrangement might be applied to it to compel the valve to close if the weight should not happen to act, and that cannot be done with the eccentric set as it now is in this model.

22 x Q. With that alteration could you cut off steam within any part of the stroke?

A. Not beyond half stroke.

23 x Q. As now arranged you could cut off beyond that?

A. [Illustrating] $\frac{3}{4}$ stroke.

24 x Q. Will it not come very near full stroke?

A. I think not.

25 x Q. Would it be proper to allow these tappets to rise up beyond a proportionable rise, which they now have, when not cutting off, to have the engine run properly?

A. As it is now set it would not be proper, because in that case if a disconnection were not effected by regulation from the governor it would not take place at all; and as the eccentric would not move the slide bar back in time to let the valve cover its port before the commencement of the next stroke, the valve would remain partially open and the steam would pass through.

26 x Q. Do you find in the working of the defendant's ma-
257 chine that there is any lateral movement produced in the tappet, or of an instrument which disengages, by any means whatever, after the stroke starts to effect this engagement?

A. That depends upon what you compare the lateral movement with. If we compare the lateral movement with reference to the line of motion of the slide bar, there is no lateral movement of the tappet after engagement; but if we speak of it with reference to the line of movement of the toe, then it does move laterally with reference to the toe after engagement.

27 x Q. In the plaintiff's is there not a curvelinear movement to that valve arm, just as in the defendant's?

A. There is.

28 x Q. Is there not, besides that, a lateral movement given to effect the disengagement?

A. There is a lateral movement given with reference to the movement of the rocking arm. By lateral movement I mean that the lines of motion of the two are not parallel, the one travelling sideways to the motion of the other.

29 x Q. You have adopted in both that arm moving in the same curve?

A. Yes.

30 x Q. I am speaking now of this instrument, and I call it a hook rod. Is there not a vibratory motion imparted to that, so that the hook end moves laterly in addition to the curvelinear motion of the arm to effect a disengagement?

A. Why, certainly it does.

31 x Q. Is there any such lateral movement of the tappet in the defendant's?

A. Why, certainly there is. The only difference is, that the tappet in the defendant's, in moving laterally, describes a straight line, moving laterally to the curved line of motion of the rocking arm; while in the plaintiff's the shoulder, while moving laterally to the line of motion described by the end of the rocking arm, describes a line which is not straight.

32 x Q. In *this* the arm moves in a curve precisely as in the defendant's?

A. Yes.

33 x Q. In the plaintiff's the hook rod has a compound motion, has it not?

258 A. Yes; it not only moves lengthwise, but crosswise. It is moved by the action of the wrist plate.

34 x Q. Is there any other than the one single rectillinear movement in the defendant's?

A. Not when you consider it abstractly.

Redirect.

48 Q. In the plaintiff's patent for this modification of valve gear, the movement by wrist plate is indicated, I believe?

A. Yes.

49 Q. It being the source by which motion is to be given to the valve gear?

A. Yes, sir.

50 Q. It is due to that movement that this compound movement takes place, I understand?

A. It is.

51 Q. This compound motion is due to the fact that it is attached to the wrist plate?

A. Yes.

52 Q. If you take off the wrist plate and attach that same valve gear to a common eccentric instead of the wrist plate, I ask whether it will not work?

A. Of course it would.

53 Q. And disengage in the same way?

A. Yes.

Further cross-examined.

35 x Q. Does he not state, in the original patent, when he has alluded to other valve gear, when such vibratory motion is not given, some means must be given to supply that?

A. Some means may be necessary.

36 x Q. For the purpose of opening the valve, I want to know whether that hook—sliding rod, as it is called—and its face is not just like the eccentric rod of an ordinary engine and its rock shaft?

A. For the purpose of merely pulling open the valve there is no substantial difference.

259 37 x Q. Now, sir, I want to know whether, in the example represented in that model, [No. 2,] what are called gauge bars in the reissued patent, and stops in the original patent, do not act as fulcra to these rods?

A. They do in this instance where the rods are moved by a wrist plate, which causes them to rock.

38 x Q. For the purpose of—taking that organization—for the purpose of effecting the disengagement of the valves at different periods, do they not mechanically act as the shifting fulchra, or the adjustible fulcra?

A. They do, certainly, act with that arrangement of the wrist plate as fulcra—that is, considering the precise manner in which they act on the rod.

39 x Q. I will ask you whether it is mechanically correct to call them gauge bars in view of that mechanical action?

A. I think it is, for this reason, that their operation is to gauge the amount of steam admitted into the cylinder before the cut-off takes place. In that view I think they may very correctly be called gauge bars.

This closed the rebutting testimony for the plaintiff.

260 On the application of Mr. Keller to the plaintiff's counsel to disclose what construction he intended to put upon the patents of Mr. Corliss, in suit—

Judge Curtis said: I shall controvert the affirmative positions stated upon the other side, which I understand to be, either that this is a patent for the special devices which are described, or else that

it is a patent for any combination of any governor with any detachable valve gear. That is their alternative. It is, they say, either a patent for the special particular devices described, and for nothing else outside of them, or else it is a patent for any governor with any detachable valve gear.

I shall endeavor to maintain that neither of these is the true construction; that the true construction of the patent and the thing patented is substantially what is described in the patent; the patentee taking care to say, in the patent, that his invention does not reside in the particular form of governor, nor in the particular form of valve gear, nor in the particular mode of detaching that valve gear; but that it is the thing described; and every imitation of it in which the defendants are imitators, has borrowed and embodied the ideas put forth in the patent.

That is all I shall go for.

(760.) Then as to patent 760, it is a claim "for the combination, substantially as described, of an air-cushion with the liberating valve gear of steam-engines." I shall insist upon the same construction, that it is a patent for the thing that is described; and there can be no question about the infringement, because you admit that, in your engines, such an arrangement has been adopted.

(759.) No. 759 is a claim for "the combination of liberating valve gear with valves which are moved parallel to their seats, and continue their closing motion after their ports are closed, and commence their opening motion before their ports open, substantially as described." If, Mr. Keller, you will suggest any doubt that has arisen in your mind about that, I will state what my answer is.

261 Mr. Keller: I have no doubt as to that.

(780.) Mr. Curtis: Then there is one remaining patent (No. 780) in which there are two claims. The first is, "combining with the rocking levers, or their equivalents for operating the valves, the shoulders on the spring bars, or their equivalents, substantially as described, and for the purpose specified." I shall say that the proper interpretation of that claim, inasmuch *as one purpose specified is a capacity to be liberated by the governor—that is one purpose specified.* I shall say, that enters into this claim; and that, if the combination of these two parts, so arranged as to have a capacity for that purpose was new, it is within this claim, and is a patentable subject. Although merely viewed as an arrangement for opening the valves, without reference to detachment or regulation, it might not be new in some cases that have been made of similar things; yet if the prior use that was made was not such an one as adapted them or gave them capacity for this new use—if they are here arranged differently, so as to be capable of this new use, and are capable of it, that is one of the purposes specified, and would render them within the claim, and patentable.

The next claim is, "in combination with the shoulders on the spring bars that operate the rocking levers substantially as described, the employment of the gauge bar or any equivalent therefor, to regulate the period of closing the valves, whether the said gauge bars

be regulated by a governor or by other means as set forth." There I shall maintain that the gauge bar is actually brought into this combination; and if that combination was new, then it is patentable, and within the claim.

The court adjourned to 9 o'clock to-morrow.

INDEX.

	Page.
Z Allen--Direct	402
" Cross-examined	405
" Re-direct	407
Wm. W. Battey—Direct	324
" Cross-examined	326
Henry B. Beach—Direct	307
Horace C. Burgess—Direct	318
" Cross-examined	320
" Re-direct	321
Charles W. Copeland—Direct	391
" Cross examined	399
" Re-direct	402
Edward N. Dickerson—Direct	310
" Cross-examined	313
Noble T. Greene	305
Henry E. Holland—Direct	294
" Cross-examined	298
" Re-direct	302
" Re-cross examined	303
Erasmus D. Leavitt, jr	336
" Recalled	411
" Cross-examined	412
Nelson Matteson—Direct	328
" Cross-examined	330
Henry B. Renwick—Direct	336
" Cross-examined	384
" Re-direct	391
" Recalled	412
" Cross-examined	414
Frederick E. Sickles—Direct	272
" Cross-examined	282
" Re-direct	293
William Spink—Direct	408
" Cross-examined	409
George P. Tew—Direct	331
" Cross-examined	334
Rense T. Waite—Direct	322
" Cross-examined	323
William Wright—Direct	262
" Cross-examined	268
Letters Patent to N. T. Greene	410

Benjn. F. Thurston, esq., opened the case for the defence, and called—

WM. WRIGHT, who was sworn and examined by Mr. Dickerson:

1 Q. What is your occupation?

A. I am an engineer.

2 Q. Engaged where?

A. In Woodruff & Beach's Iron Company, Hartford.

3 Q. Have you been several years engaged in the construction of steam-engines, as engineer to Woodruff, Beach & Co.?

A. Between seven and eight years.

4 Q. Will you look at this model of the French machine?

Judge Curtis objected to the witness being examined in relation to this model before proof had been given of its publication.

The court thought it would be better to take the testimony, subject to objection hereafter.

5 Q. Have you been building machines similar to that in any respect; and if so, in what particulars; and when did you make the first one on that plan? Describe wherein there was any difference.

A. The helical cam was similar to this. That was on the first engine I made there—seven years ago.

263 6. The court: Was that all the difference?

Witness: Well, it had a regulator attached to it. It had the ordinary regulator attachment attached to the helical cam rod.

7. Judge Curtis: Did you say that was the only similarity?

A. Yes, sir.

8. The court: How long ago do you make that?

A. I cannot give you the exact date.

9 Q. About how long?

A. Between six and seven years, I should think.

10 Q. Was the governor like that attached to the helical cam rod?

A. No—a common governor.

11. Mr. Dickerson: What effect did that governor have upon the helical cam rod? How did it operate?

A. It operated very nicely, indeed.

12 Q. Describe how it operated.

[Objected to. Objection overruled.]

13 Q. I asked you how the governor was connected, and you said to this sliding rod?

A. Yes.

14 Q. How was it connected?

A. With a bell crank.

15. The court: That relates to patent No. 763?

Mr. Dickerson: Yes, sir.

16 Q. You have explained that a fly-ball governor was attached to the rod that worked the cams by a bell crank in the first engine you made?

A. Yes, sir.

17 Q. Tell us what a bell crank is. Do you see one on that model?

264 A. Those right angle levers *there*. One end of the bell crank was attached directly to the governor, and the other directly to the helical cam rod, and the centre or the corner of the bell crank was fastened to a standard, so that as the governor altered it altered the helical cam rod in the same proportion that the governor's balls expanded or contracted.

18. The court: Longitudinally?

A. Yes, sir.

19. Mr. Dickerson: Go on.

Witness: This governor stood directly over the cam rod, the same as to put it on *there*, [illustrating,] and one end of this bell crank was attached to the rod with collars, *here*, [in the French machine model] and the other took hold of the governor, so that any motion of the governor would move this rod longitudinally in the same proportion that you move the governor.

20 Q. When the engine's speed was accelerated, what effect was produced on the cut-off?

A. The effect was that it would cut off the steam short. The balls would expand more.

21 Q. And as the engine went slower what effect would that produce?

A. The balls would fall and admit more steam.

22 Q. What kind of valves were used in that engine?

A. Slide valves.

23 Q. Where was that engine set in operation?

A. At the Payne mills, at Bridgeport.

24 Q. Is it still in operation, sir?

A. I believe it is, sir.

25 Q. How did it regulate? I speak in reference to the perfection of regulation.

A. I never heard any complaints about it.

26 Q. What kind of work was that mill doing?

A. Weaving and spinning woolens.

27 Q. Do weaving and spinning woolen require regularity in the machinery?

A. Yes, sir.

265 28 Q. Since that time, Mr. Wright, have you made other engines with the cam cut-off operated upon by the governor substantially the same as *that?* [French model.]

A. I have made other engines with an expanding cam. I took out a patent for it in 1854, I think. I do not know how many we have made—but some hundreds, I should think.

29 Q. You made one at the Thompson carpet mill, I believe, sir?

A. We made part of an engine there; removed the old cylinders, and put on new cylinders of larger diameter.

30 Q. And new valve gear?

A. Yes.

31 Q. Was regularity in that mill of great consequence?

A. It was.

32 Q. How did you first regulate that engine?

A. In the ordinary mode in which we make all our engines, with that expanding cam and common fly-ball governor.

33 Q. How good was that regulation? How perfect was it?

A. It was so perfect that you could not discover any difference in the working of the engine, but you could see it in the picks of the loom.

34 Q. How did you remedy that defect, sir?

A. I made an attachment of a mill-governor to the other governor, and the mill-governor regulated the imperfections of the other governor.

35 Q. What was the effect of that, sir?

A. The effect of that was to give them a satisfactory speed.

36 Q. Do you know within what range that will regulate?

A. I cannot tell you exactly. It would be difficult to tell.

37 Q. Can it be told by counting at all, sir?

A. No.

38 Q. Does the ear now give you any intimation about it in the spinning or weaving of any irregularity?

A. I could not discover any. I never could see any varia-
266 tion before this attachment was put on, but the weavers all agree that it was a great improvement.

39 Q. How was that mill-governor constructed? Was it like *that*, sir? [French model.] What was the construction of it?

A. I should think it was exactly like *that*, sir. That was the governor that was on the engine previous to our making alterations.

40. The court: That was at Thompsonville?

A. Yes, sir.

41 Q. Was it a geared mill-governor?

A. Yes, sir.

42 Q. So that the balls by their action engaged it to go in one direction?

A. Engaged the tappets instead of the gear. The gear was always running and working in another direction, working on a screw. It was in principle the same as *this*, but not like it. The tappets were so close that these balls could move but very little without engaging the lower one or the top one, so that the balls always kept within a certain plane; that is, they travelled a certain distance from the centre, and as the balls expanded it engaged this wheel, turned a screw, and let on more steam, until the speed was brought up to just what was wanted, and then it would disengage, and if the regulation was right the wheel would turn between the two. If it went *this* way [illustrating on French machine] the balls would depress and

turn a screw in the corresponding way, so as to shut steam off and let it on as was required.

43 Q. It was the well-known form of mill-governor?

A. Yes, sir; the common form of mill-governor.

44 Q. In all those hundred engines, be they more or less, that you have in operation, did you have any difficulty in regulation?

A. No, sir; not the slightest.

45 Q. Have you any rolling-mills in operation?

A. Yes, sir.

46 Q. Where?

A. The only rolling-mill that has got the expanding cam on is in the New Bedford rolling iron works.

267 47 Q. Does that regulate the rolling-mill, sir?

A. They have always spoken very well of it, and I have never heard of any complaints.

48 Q. Have you ever seen it at work there?

A. Not lately.

49 Q. At any time?

A. Soon after it was started.

50 Q. How did it operate then?

A. Very well, sir.

51 Q. Have you ever heard any complaint of it since?

A. Not at all; only the remarkable feature there is in the engine of the correctness of its regulations.

52. The court: That has your patent cam on?

A. Yes, sir.

53. Mr. Dickenson: Will you tell the court how that patent cam of yours differed from *that* cam? [French machine.]

A. The difference is that it does not require any longitudinal movement.

54. Mr. Stoughton: The cam itself?

A. Yes, sir.

55. Mr. Dickenson: Go on and describe it further.

A. The rod that passes through the cam and connects with the governor changes the eccentric ring that is on the inside, and carrying it round it projects out, a portion of it, more or less, just as the governor chooses to set it. The time of opening the valve is always the same, and this projecting piece is the same that the stem rests on.

56 Q. The cam is made in two parts?

A. Yes.

57. One part within the other, and the inside part comes out like *that?* [illustrating.]

A. Yes.

58 Q. The longer the duration of the contact of the rolling lever upon the cam?

A. Yes.

59 Q. How is that shifted in and out?

A. By a spiral groove between the two.

628 60 Q. How is the spiral groove operated?

A. By *this* rod [referring to French machine.]

61 Q. That is shoved in and out?

A. Yes.

62 Q. In place of shifting the whole of the cam, a part only is shifted?

A. Yes.

63 Q. And that is done by the spiral groove between the two pieces?

A. Yes.

64 Q. Has it a feather?

A. It has two.

65 Q. Explain what a feather is.

A. A feather is a piece of iron fastened into the rod like *that*, where there is another piece passing over it. You want to move longitudinally, and at the same time keep the other piece from turning round. The feather slides between the two.

66 Q. It is a ridge?

A. Yes; you keep the same relative positions all the time by the feather.

67 Q. It is a long screw-thread?

A. Yes.

68 Q. As you push this rod in this spiral groove pushes the cam in, and as you draw the rod out the spiral movement draws it out?

A. Yes, sir; that is a key on the model, but it is the same as a feather.

69 Q. Has *that* cam any other office in regard to the regulation than this one? [on French machine.]

A. I do not know that it has.

70 Q. It grows longer as the governor shuts together and shorter as the governor opens?

Cross-examined by Mr. Stoughton:

71 x Q. You were once, seven or eight years ago, in the employ of Mr. Corliss—were you not?

A. Yes, sir.

72 x Q. In his employ after he commenced building his engines with his mode of regulation?

269 A. Yes, sir; for some time.

73 x Q. I understood you to say that about seven or eight years ago the concern in which you were employed built one engine having a cam upon which the valve rose or was moved, connected directly with the governor?

A. Yes, sir.

74 x Q. Or, rather with the slide of the governor?

A. Yes, sir.

75 x Q. And the purpose of that was, I suppose, as the balls of the governor moved to change that position by the movement of the cam?

A. Yes, sir.

76 x Q. Did you ever build more than one of these machines?

A. No, sir.

77 x Q. Did you try to build another in Providence previous to the time you put this one in operation?

A. I have forgotten. I have built one with a helical cam, in Providence. It was never completed.

78 x Q. You tried to make it work?

A. I never tried it.

79 x Q. Did others try to make it work?

A. I do not know whether they did or not. It passed out of my hands and I had nothing more to do with it.

80 x Q. Did you have any information whether they did or not?

A. I do not know as to that.

81 x Q. Now, sir, did you ever make a steam-engine having a mode of regulation like *that* [French model] which you see before you?

A. Not with that kind of a governor. Every other part of it was very similar in principle.

82 x Q. Was your expansion cam similar in principle to *that* cam?

A. Yes.

83 x Q. The difference being that it did not move longitudinally. I asked if you considered your expanding cam arrangement the same as *that* before you?

A. The expanding cam produces all the offices that that does.

270 84 x Q. Do you consider your expanding cam the same as that arrangement before you?

A. I do not consider it the same as *that*, but it will produce the same effect.

85 x Q. Do you consider it substanially different from that?

A. Yes, in the mechanical construction of it. In principle it produces the same result.

86 x Q. That is to say, your cam regulates, and if this will regulate, it will do what you do. Is that what you mean?

A. Yes.

87 x Q. Does your cam move longitudinally for the purpose of giving a short or a long cut-off?

A. No, sir; the cam does not move at all longitudinally.

88 x Q. But what you call your cam rod does?

A. Yes, sir.

89 x Q. Now, to what is your cam rod attached when you use your expansive cam?

A. To the governor.

90 x Q. And your purpose is, by an upward and downward movement of the balls to give a corresponding movement to this rod?

A. Yes.

91 x Q. And that rod actuates your cam?

A. Yes.

92 x Q. You have an instrument between your governor slide and expanding cam which produces this expansion?

A. Yes, this spiral groove.

93 x Q. Repeated.

A. Yes.

94 x Q. And your governor moves this slide, which is the instrument to effect it?

A. Yes.

95 x Q. And that instrument being set in position effects a change in the particular form of this cam by expanding it or suffering it to contract?

A. Yes, sir.

96 x Q. Now, sir, did you understand, when you got your patent, that you had made a substantial change in the operation of cutting off and regulating?

271 A. I understood that I had made a change in the mechanical arrangements.

97 x Q. Now, sir, you say, for the purpose of getting a more perfect regulation of this machine in the carpet mill, that you connected your governor, which, through its slide, acted upon this expanding cam, with what you call the "mill-governor?"

A. Yes, sir.

98 x Q. And you still used your governor to regulate it and added this to that. Is that so?

A. Yes.

99 x Q. How do you connect your mill-governor with your other governor?

A. It was connected by two sliding weights.

100 x Q. With what were the weights connected?

A. With a lever attached to our common governor.

101 x Q. Then the mill-governor was attached directly, or in the way that you have mentioned, to the other governor, and it was to steady the other governor that the mill-governor was added?

A. It was to correct the imperfections of the other governor.

102 x Q. That governor which you *see* is a fly-ball governor?

A. Yes.

103 x Q. And the fly-ball governor proper is *that* part of the instrument which you see *here* projecting with the balls upon the ends?

A. Yes.

104 x Q. That part attached to it you call a mill regulator, consisting of cog wheels, &c.?

A. That is a new term to me.

105 x Q. And *that* part is called the mill-governor?

A. Yes. I have seen the same kind of governors used on steam-engines.

Redirect.

106 Q. What constitutes the governor in *that* machine?

A. I should consider the governor was the expansion and contraction of *these* balls, which regulates the quantity of steam into the cylinder.

272 107 Q. What is your opinion of this mill-governor as compared with the other kind as a regulator?

A. I think for a very nice steady power without any variation that the mill-governor is the best thing there is.

108 Q. Is the mill-governor more accurate than the fly-ball governor?

A. It will regulate closer when properly made.

The court adjourned to Monday, 24th, at 9 o'clock.

MONDAY, Sept. 24th, 1860.

The court met at 9 a. m.

FREDERICK E. SICKLES, called by the defendants, sworn.

Examined by Mr. Dickerson:

109 Q. You are the patentee of what is called the Sickles cut-off.

A. Yes.

110 Q. Will you state to the court any facts within your knowledge relative to the use of the air dash-pot in combination with the liberating valve gear by yourself or within your knowledge?

A. Well, I would say that in constructing these machines and getting them in shape, the directions I gave was to grind the plungers in. That is not necessary for the use of water to grind them in, but it is for the purpose of insuring that the fitting is not had by the workman—as a sufficient direction to insure an accurate fit for the water. When so fitted they would then be sufficiently tight to work on air. It was my custom, when I saw them in that shape, to try them. If they worked on air I knew they were tight enough for water, and I used to expect always to use water in them. In some cases where the water got out, where the engineers were not familiar with the way in which the thing was intended to be worked, they would screw down the plunger as the valve slammed until they got
273 it down low, and it would go on working on air, and they supposed they had remedied the difficulty, and would not bother any more about it. My custom was to tell them not to do so, but to keep the plunger in a certain place, and to keep in water enough to work on water. I thought it was better. Some of the difficulties I had in regard to that was, that the engineer, not comprehending the plan I went on, would screw the plunger down to too great a distance; the effect was that they really worked them on air, with only as much water as would fill up the space between the bottom of the plunger and the bottom of the pot. That would create a prejudice against the machine, and I would advise them to fill them with water, and not work them with air in that way.

111 Q. Have you ever shown the operation of it on air?

A. I can say that I have shown it to one person, to Mr. Taylor—the great reliability with which it could be made to work on air. I exhibited to Mr. Taylor, in 1843 or 1844, the resistance of the air, if you had it nicely fitted. I always preferred to work on water, because getting into the hands of men that would let dirt into them they were liable to rust. Where they had to be constructed in different shops, by different persons, you cannot have that accuracy that you would in one shop worked by the same tools and gauges.

You cannot express the fit of a dash-pot in drawings; therefore I took this plan to insure accuracy.

112 Q. Did you ever, in actual practice, work an air dash-pot on your cut-off?

A. I can say I have done so for curiosity. I have on some of them, above the water dash-pot, put an air cylinder for the purpose of forcing the valve down, and making a vacuum by the lift. In some instances I have opened the cock and let the upper cylinder draw in air and expel it. Where I put an air cylinder on the top of the water cylinder to make a vacuum, to draw it down, I have opened a little cock to see how it would work. When the valve was slamming without water, I shut the cock again and put in water. I have seen others do it, and have done it for curiosity.

113 Q. Do you recollect the steamboat *New Haven*?

274 A. Yes; I worked one of the dash-pots there for about a week, on air, before I left; but I put in water before I left it.

114 Q. What year was that in?

A. In 1844, I think.

115 Q. How did that work?

A. It worked very well. It was a tight fit while working. It would have worn, though, after a time. In a steamboat, where they are burning coal and using a blower, and dirt flying about, it would have worn: so when I left the boat I put water in.

116 Q. When you left the boat you put water in?

A. Yes. I filed the bottom of the plunger a little more rounding, and put water in.

117 Q. Explain to the court the difference between the use of air and water, as you found it—the difference of its effect, and the difference of the machine to produce the best effect in each case.

A. The difference would be that in using air you would require the plunger to go in deeper—the retardation would be during a longer portion of the stroke. In water you could arrest it more suddenly, because the water is a more unyielding medium, and of course arrests with greater suddenness. Therefore it is more desirable to have the plunger more round when you use water, because otherwise the arrest would be violent. Though it will work on water or air, one or the other. The greater the amount of weight upon it, the more I would round the plunger as a general rule.

118 Q. You say you exhibited to Mr. Taylor one of the dash-pots worked on air. What was the effect to be accomplished by that?

A. In 1843 or 1844. I had been busy in putting up a little engine in the *Sun* printing office, and I noticed a difficulty about the bed of a printing press coming up with a slam. Knowing Mr. Taylor, I brought him and showed him one of the dash-pots working on air, and told him that would be the thing for his printing presses.

119. What did he do?

A. He adopted it. I believe, to the printing press, subsequently. I have seen them at work since.

275 120 Q. That is a common device now for arresting the slam in printing presses?

A. It is in some cases.

121 Q. The reciprocating presses?

A. Yes; but it was not, of course, made in the form of a dash-pot. It was a straight cylinder, as he used it with the press. He drew the plunger entirely out from the secondary reservoir, and made the plunger fast to the bed.

122 Q. Do you see them running in that way on engines now?

A. I have seen them running in that way on printing presses.

123 Q. Look at this publication. [Circular of Sickles and Cook.] Was that published by you?

A. Yes, by myself and Mr. Cook.

124 Q. What is the date of it?

A. 1844.

125 Q. Before going into that; about the *New Haven*, was that a reciprocating cut-off?

A. Yes, sir—a Sickles cut-off.

126 Q. Where was she running?

A. She was running up Long Island sound. The boat was started up before the cut-off was done, and I went in her. It was while I was in her that I tried this experiment, and when I left her I filled the plunger-pot with water.

127 Q. This circular was published by you in 1844?

A. Yes, sir; I do not recollect the date now; but I have no doubt that is correct.

128 Q. Look at that circular and see what steamboats are referred to there as having been fitted by you with cut-off.

A. I read: "The above cut-off has been constructed, according to the direction of Mr. Sickles, for the following steamers: *The Charter Oak*, *New Haven*, *New York*, *Rhode Island*, *Massachusetts*, *Highlander*, *Mohegan*, *Burlington*, and U. S. steamer *Missouri*."

129 Q. What shop was the *Rhode Island* fitted up at?

A. The *Rhode Island* was fitted up at Secor's Works.

130 Q. There was one fitted up at Providence?

276 A. The *Rhode Island's* machinery was put on in Providence. The work was made at Secor's, and I came on with it to Providence and put it on there.

131 Q. At whose shop was it in Providence?

A. The work for fitting it on, in the shop of Barstow, Fairbanks & Co.

132 Q. Was Mr. Corliss there at that time?

A. Not that I know of, sir. I do not recollect seeing him.

133 Q. Refer to that part of the publication in reference to its use upon the various kind of valves.

A. I read here: "This cut-off can be applied to low as well as high pressure engines, to puppet valves, single or double, and likewise to slide valves."

134 Q. Will you explain to the court how you applied this cut-off to the *Highlander*, and the kind of cut-off valve there?

A. They were double puppet valves—what are now called balance valves, more generally. They were brass valves, and I bolted a ring on the bottom side of the valve about five-eighths of an inch deep,

to fit a hole in the chest. The idea was to get a lead on the exhaust; that was one reason why I did it.

135 Q. Explain how that operates.

A. It is a plug, bolted on the bottom of an ordinary valve; the same as you bolt a plug on the bottom of this, to fit this ring.

136 Q. Court: That is what you call a check ring?

A. It is used as a check ring.

By Mr. Dickerson:

137 Q. How was it fitted?

A. It was fitted as tight as you could fit them without jamming; of course the word "fit" is a term "as tight as you can fit it." Some fits, of course, are perfectly tight; it was as tight as you could fit it, with safety.

138 Q. As tight as the mechanical work could be done?

A. Yes.

139 Q. Was it intended to be made tight?

A. The intention was to make it tight for about three-eighths of an inch, and then round the bottom edges, so that in coming in it would not catch.

277 140. Court: Was that in the same way as your cylinder was ground in the puppet valve?

Mr. Dickerson: The same feature?

Witness: One object was: As the rod working the exhaust valve also worked the steam valve, and as you wanted a greater lead *here*, to open the exhaust valve earlier than the steam valve, it became necessary to put on something to do it.

141 Q. That valve moved after it had closed its port, both in opening and closing?

A. Yes, sir.

142 Q. What year was that on the *Highlander?*

A. In 1844, I believe. I put on that when I put the cut-off on her; I did the work at the same time.

143 Q. Have you applied that same arrangement in others?

A. I have made drawings for a number since I gave the directions; whether they were so done or not, I do not know. I made drawings for valves in the steamboat *Bibb;* whether it was done or not, I do not know. There I made the ring much deeper; I made it an inch deep. I do not know whether they were done or not. I made the cylindrical part an inch deep, so that the valve would work an inch before it was opened; I wrote directions to them to be careful to make it a tight fit. I may say the ring is a common device now—that is, they use it in Baltimore. Mr. Reeder has put it on a number of engines since I put it on engines in Baltimore—that is, I gave directions to have it done. I do not recollect that I examined them.

144 Q. You instructed them to be so made?

A. Yes.

145 Q. When was that done in Baltimore?

A. About 1845 or 1846, when I was there.

146 Q. In this valve, in closing, does it close the port before it is arrested?

A. Yes, sir.

147 Q. It moves after it closes the port?

A. Yes, sir, until the valve touches the seat, of course.

148 Q. Overlaps?

A. Yes.

278 149 Q. Explain to the court the effect of opening steam valves rapidly, and the devices resorted to for controlling their opening. What is the desired effect?

A. In putting on a check ring, the bottom end being round, has two purposes; to give the steam easy, that is one.

150 Q. That is a desired thing to be done?

A. The desired thing to be done is a little more than you can do. You cannot get it to perfection.

151 Q. You can tell what would be perfection in the opening of the valve?

A. The perfection of opening a valve would be not to give the steam to the engine, or give power to the engine, until after the crank had passed the centre. There is a point past the centre where the pressure upon the piston will be of no use until it arrives at a certain leverage, which leverage is sufficient to overcome the friction. That is the perfection of the application of power to an engine, but you cannot get that perfection in practice. Then, so far as preserving the machinery is concerned, it would be proper to arrest the momentum of the parts as gradually as possible, so as not to have any of the parts subject to too great a pressure. That would be the perfection in practice. It is important to keep in mind both these, and to so apply the steam as that when the piston is coming over the centres, to get the necessary easy application of steam, and to have it fill up the cylinder, when the piston has got to that point where it will be serviceable. When the piston is upon the centres there should be a small amount of clearance, for there is a small amount to be filled, the piston moving very slow, and a very slight opening will be sufficient to give the steam required. The best arrangement is to have something adjustible, so that if the engine has any jar you can adjust the application of the steam while the engine is running, letting the engine decide for itself, and let it be gradually supplied to avoid the jar. That is the perfection of it. In practice on large engines where there is a good deal of spring to all the parts it is quite an important matter to get the valve opening slow on the centres, and to have an adjustment to open rapidly after the piston begins to move.

279 152 Q. Is there any slide valve, any ordinary slide valve, or any you know of, that opens slow enough?

A. I should prefer to open them slower than the slide valve generally opens.

153 Q. I speak of the square slide.

A. I think not—not at the first of the opening. After the pressure is on they should be opened as rapidly as possible.

154 Q. What devices are resorted to to make the slide valve open slow?

A. They are bevelled.

155 Q. On puppet valves is there any difficulty about opening them fast enough?

A. No difficulty about being fast enough, so far as the steam valve is concerned.

156 Q. Is there any difficulty about their opening slow enough?

A. There is some difficulty in large valves in opening them slow enough. Although in the shop you may make them open slow, there is always a spring in all those parts that will hold on and suddenly yield. The elasticity of the metal will give them a slight impulse when they first start, at the very time you want them slow.

157 Q. What methods are resorted to in the construction to avoid the evil of suddenly opening puppet valves?

A. There is one way of working engines with puppet valves—to close the exhaust valve before the end of the stroke. The effect is to shut in some of the steam, and then the piston, descending presses against that steam, and gets up a pressure the other way before the steam valve is opened; and then the slack of the engine being taken up on the cushioned steam, the blow does not have a bad effect.

158 Q. What is the effect on the power?

A. I think it diminishes the power.

159 Q. How is that loss of power remedied—by opening the steam valve slowly?

A. If you put something on the steam valve that is capable of opening it with regulated speed when it first starts, you can keep the exhaust valve open.

280 160 Q. Were you in court when Mr. Nightingale testified about taking out the Sickles cut-off?

A. Yes, sir.

161 Q. Were any of those engines built by your directions, or do you know anything of them?

A. No, sir; I recollect seeing only one; that at the Delaine mill in Olneyville.

162 Q. Had you anything to do with the construction of any of those engines?

A. No, sir; and no interest in them.

163 Q. You saw the one at Olneyville, Delaine mill, running once?

A. Yes, sir.

164 Q. What kind of engine was that?

A. There were two very large square engines when I first saw them. They appeared to be out of order and out of line, and the cut-off was not working well when I saw them.

165 Q. Were they running with the economy due to the machine?

A. No, sir; I thought not all.

166 Q. Explain to the court the effect produced upon economy by

the use of the Sickles cut-off, properly or improperly used, and some facts in your experience about it.

A. If you make the plunger descend too far it is injurious. In using it in practice the difficulty was to instruct the engineers. They started with the idea that it was the quantity of water which determined the dropping of the valve, and they, in fact, worked on air and water. When the valve slammed they would screw the plunger too far down. When it ran so as not to give them much trouble they would say it worked beautifully. That was their idea of the utility of the machine.

167 Q. Tell the court the effect of putting on the Sickles cut-off engine the same motion that the Corliss motion has on it—the coexisting movement—within your experience.

A. The valves were put in order and the coexisting movement added, and it was in effect another engine; I presume double the power.

168 Q. Now take the case of the *Augusta.*

281 A. She was in New York, and I superintended the fixing of her. She had my cut-off on her, and I put on the coexisting movement. Before that she made 16 or 17 revolutions; after it was on she made 23 revolutions a minute.

169 Q. There was no governor put on that?

A. No, sir.

170. Court: What is the coexisting movement?

Mr. Dickerson explained on model: the two valve rods, by moving at the same time, each one should move more than half a revolution of the engine.

171 Q. Will you describe to the court, in reference to the Augusta, to which you applied the coexisting movement—what else did you do?

A. We fixed the cut-off to the valve; we put in new valves the same shape as the old ones, the old ones being worn out.

172 Q. What was the effect in relation to the steamboat?

A. The effect was to double the power of the engine.

173 Q. We tried her to find what she would do before altering her?

A. Yes, sir; and then tried her after she was altered.

174 Q. No governor was put on that?

A. No, sir.

175 Q. Now, you speak of the "old valves," were they old valves—taken out?

A. They were brass valves. I said "old valves" from the fact of taking them out.

176 Q. They were valves in perfect order?

A. I think they leaked some. We took out the brass valves, put in iron valves, and fitted the cut-off to them.

177 Q. In putting an indicator on the engine what information do you derive from that?

A. It gives you a criterion by which to judge of the state of the engine.

[Mr. Dickerson called on plaintiff to produce the indicator cards referred to by Mr. Nightingale in his evidence.]

178 Q. Does the indicator show what the difficulty in the
282 engine is, whether in the condition of the engine or the condition of the valve gearing?

A. It will give you an indication of the condition of the engine, and how much it can be improved. A person familiar with it can tell how much he can improve it, and what the difficulty is on the engine.

Cross-examined by Mr. Stoughton.

179 x Q. You have spoken of an engine which you altered, taking out brass valves, repairing her, and changing her. In what concern was that engine used?

A. On board the steamboat *Augusta.*

180 x Q. How long had it been there?

A. About 20 years, I believe.

181 x Q. Did you originally construct the engines?

A. No, sir.

By Mr. Dickerson:

182 Q. In regard to your application at the Patent Office after you took the patent out, did you make any application about a patent for putting the governor to it?

A. My recollection is indistinct as to that. I recollect talking about it. I inquired, I think, if I could patent the application of the governor to my cut-off.

183 Q. What reply did you get to it?

A. I was told that I could not patent it.

184 Q. Who did you inquire of?

A. I think I asked Mr. Keller at the time.

185 Q. Mr. Keller was then an examiner?

A. Yes, sir; I was acquainted with him and I asked him.

186. Mr. Stoughton: Mr. Keller was your authority? I ask, because it was he who drew the application of Mr. Corliss for his first patent.

Mr. Keller: Yes, and I will have a word to say about that.

By Mr. Stoughton:

187 x Q. Where was the steamboat *Augusta* when you made these changes?

283 A. In New York harbor.

188 x Q. How long had she been in New York harbor in use?

A. Very little—perhaps six months.

189 x Q. Where had she been in use?

A. She had run about New York harbor for several years, and from Washington and Acquia Creek, then sold and brought back to New York, and bought by these parties.

190 x Q. Who put in her engines?

A. I think they were put in originally by Mr. Cunningham.

191 x Q. Who put in the cut-off that was used?

A. I think I put in the original cut-off that was used.

192 x Q. How long ago?

A. 8 or 9 years ago.

193 x Q. When did you put in the coexisting movement?

A. I put that on about a year ago.

194 x Q. Can you tell when it was?

A. About a year or a year and a half ago.

195 x Q. Was not that engine in poor working order when you took hold of it?

A. Yes, sir; it was.

196 x Q. What was her size?

A. 32-inch cylinder, 11 ft. stroke.

197 x Q. Who owns the boat now?

A. I think the Florida Steamboat Co.

[Mr. Dickerson states that he is the owner.]

198 x Q. In the use of slide valves it is necessary, after the valve has covered its port, that it should overlap it a little?

A. Yes, sir; it is.

199 x Q. I mean slide valves that move parallel, as Mr. Corliss' does?

A. Yes, sir.

200 x Q. Do you know the Seward valves?

A. I know, them, sir.

201 x Q. He was an English engineer?

284 A. I am not sure.

202 x Q. How long have you known of their existence, either by publication or practice?

A. I cannot be sure of that—a great many years. I have heard of them a number of years ago.

203 x Q. Do you know how they work?

A. I have got a general idea. There is a separate valve for each end of the cylinder.

204 x Q. The steam valves and exhaust valves all move toge'her?

A. The exhaust valve on one side and the steam valve on another.

205 x Q. When one steam valve moves the other does?

A. Yes, sir.

206 x Q. And when giving lap to that arrangement you lap one for the purpose of opening the other?

A. I have not examined the drawing to see how they work.

207 x Q. Is not that your idea of how they work?

A. I presume that is the idea.

208 x Q. That is you increase the lap on one valve after it is closed for the purpose of overlapping the port of the other in the Seward valve?

A. I think that is it.

209 x Q. Then the rods by which the valves are moved, have they the coexisting movement in that arrangement?

A. They have the same movement. There is but one rod, if I mistake not.

210 x Q. I want to know whether the valves have not a coexisting movement for the purpose of lapping one valve while the other is being opened?

A. Yes, sir.

211 x Q. As you understand it, you say that the two steam valves in Seward have a coexisting movement when they are working?

A. Certainly, sir.

212 x Q. And that is for the purpose of giving lap to one while the other is opening?

A. I cannot say that.

213 x Q. Do you not believe that is so?

A. I cannot believe a thing I do not know.

285 214 x Q. Have you not some idea that that is so?

A. Bring me the drawing and I will tell you.

215 x Q. If one does move to overlap, they have that coexisting movement?

A. Yes, sir; in one sense it is a coexisting movement.

216 x Q. Is there any sense in which that is not a coexisting movement of the two parts?

A. No. sir; I think it is coexisting.

217 x Q. Then, for the purpose of overlapping one steam valve, being a slide valve, while you open the other you must have a coexisting movement, as you understand it?

A. Yes, sir.

218 x Q. You do not overlap the ordinary puppet valve?

A. If you use a check ring, you do overlap.

219 x Q. Take your puppet valve, as ordinarily employed by you without a check ring, is there any overlapping to it?

A. Without the ring there is not, sir.

220 x Q. In other words, as soon as the puppet valve begins to move, as ordinarily constructed, it begins to open its port?

A. Yes, sir; without a ring.

221 x Q. Then, for the purpose of opening one of your valves while the other is being closed, you never open one of your valves while the other is being closed?

A. That depends entirely upon the valve.

222 x Q. I speak of valves without a check ring.

A. Working the puppet valves without a check ring you do open them a trifle, but not very much.

223 x Q. Is that a coexisting motion for the purpose of opening the lap?

A. Not without the ring.

224 x Q. When you use the ordinary slide valve it is otherwise?

A. Yes, sir.

225 x Q. Now, I think, you said there was a difficulty in making puppet valves open slow enough?

A. Yes, sir.

226 x Q. Is not that because the moment you set in motion
286 the part which moves the valve you begin to open the valve port itself.

A. It is, without the ring.

227 x Q. When you move the slide valve for the purpose of opening its port you move it a little way before the port begins to open, where it overlaps?

A. Yes.

228 x Q. And when you reach the port of the slide valve, so that it begins to open, it is important to open as quickly as possible to prevent wire-drawing?

A. No, sir. It is important to open slowly at first.

229 x Q. Is it important that the port of the slide valve should close quickly?

A. It is, sir, because the more rapidly it closes the better it prevents wire-drawing.

230 x Q. What particular advantage is there in closing the port quickly?

A. To prevent wire-drawing.

231 x Q. Does not the same reason require you to open it quickly?

A. No. The piston is in a state of rest, and the smallest amount of steam let in will be sufficient. The pressure on the centres is of no use. It makes friction on the engine which it is obliged to overcome, and which it has to drag over its centres. I was in considerable doubt for a number of years as to how the Cunard steamers worked so well until I found that they closed their exhaust valves, and cushioned.

232 x Q. Those were heavy valves?

A. Yes, sir.

233 x Q. Your idea is, that it is important when you begin to open the valves of engines which operate cut-off valves, that you should begin to open the ports and admit steam slow?

A. Yes, sir, without reference to being cut-off valves.

234 x Q. Is there any point at which the valve should be opened quick?

A. Yes; immediately after having pressure on the engine it should work quick. To get pressure on slow, and then open quick.

287 235 x Q. There is a point in opening when the valve should open quick?

A. Yes, sir, quicker than when it first opens.

236 x Q. Is it true that it is an advantage that it should move quick, when it does move quick, to prevent wire-drawing?

A. Yes, I mean it should move quicker than is required for the first opening; first slow, and then quick.

237 x Q. When it is to move quick it is to prevent wire-drawing?

A. Yes, sir.

238 x Q. What kind of valves did you put into this engine of the *Augusta?*

A. They were the ordinary balance puppet valves.

239 x Q. Had they the check ring?

A. No, sir.

240 x Q. Did you give the valves lap, on the *Augusta?*

A. No, sir.

241 x Q. You did not use the coexisting motion to overcome that lap?

A. No, sir. I used it for other purposes.

242 x Q. For what purpose did you use it?

A. It secures a number of objects. In the first place, you need not put on as much lead on the eccentric. There is a large amount of slack in the engine. (Witness points out where "slack" occurs at the different joints.)

243 x Q. You mean that when anything is to be moved, that moves through the intervention of joints, or otherwise, you will have to move an appreciable trifle before you really get started. They do not fit perfectly together?

A. Yes, sir.

244 x Q. That is so in all machinery you ever heard of?

A. Yes, sir; and it is an item in valve gear that is important.

245 x Q. Tell me the use of so much slack as I see in *that*, (C.)

A. To give more lead on the exhaust valve.

246 x Q. Is that all?

A. It enables you to let the engine follow full stroke on the steam valve.

288 247 x Q. And giving a little slack *there* enables you to take hold and lift the valve too?

A. Yes, sir; you have to make sure it will take hold.

248 x Q. Have you not got to get rid of all that slack by changing the position of the eccentric very slightly?

A. No, sir; the set of the eccentric will not give you that slack. You have got to make a space in *there*.

249 x Q. Cannot you take up that slack without the coexisting movement by a set of the eccentric?

A. It could not then follow near full stroke.

250 x Q. In the cut-off engine is that of any consequence?

A. Not so much.

251 x Q. In a cut off engine, where you always cut off within half or $\frac{3}{4}$ths the stroke, may not that slack be given by a set of the eccentric?

A. Not without another difficulty, that you cannot get a lead on the exhaust valve ahead of the steam valve. I speak now of the engine without the check ring; if you put the check ring on, it alters that.

252 x Q. I speak of the use of that with your puppet valve.

A. I may say this model was not made with reference to puppet valves especially. It was made to represent *a* valve, without reference to the kind of valve.

253 x Q. Is it applicable to puppet valves?

A. Yes, sir, and slide valves.

254 x Q. Was this engine of the *Augusta* the first one you put this coexisting motion to?

A. No, sir; I put it on to others before.

255 x Q. What other engines?

A. I put it on to the *Osceola* in 1845.

256 x Q. Had that the ordinary puppet valve?

A. Yes, sir.

257 x Q. Without the check ring?

A. It had not the check ring.

258 x Q. Did you give the coexisting motion there for the purpose of overcoming the lap?

A. Not in that case.

259 x Q. There was not any to overcome?

A. No, sir; where the valves are very steep they open very slowly.

289 260 x Q. Did you put it on to any other?

A. I have occasionly put it on to engines. I put it on to the old steamer *Columbia.*

261 x Q. When was that?

A. In 1844, before I took out the patent.

262 x Q. Had that the ordinary puppet valve?

A. Yes, sir.

263 x Q. Without a check ring?

A. Yes, sir.

264 x Q. Did you ever put it on to any except engines having ordinary puppet valves?

A. No, sir.

265 x Q. Now, go back to the use of air to prevent the slam of the valve. I understand you to say that an engine you looked at in Rhode Island, in the Delaine Mill, was badly used with reference to the management of the water in the dash-pot. State to me what the management was that was had, and produced the bad effect.

A. I did not say particularly of that engine. I saw the engine was working in bad order. It was in terribly bad order.

266 x Q. That was a difficulty that would grow out of not attending to putting water in the dash-pot?

A. It does not result from that directly, except in the slamming.

267 x Q. I thought you said that engine seemed not to be working properly; that at a certain point the valve did not close. What was the reason?

A. Because they had screwed the plunger down too low.

268 x Q. So that the plunger would not go low into the cap?

A. Yes, sir.

269 x Q. If there had been less water, would that remedy it?

A. Yes, sir; some.

270 x Q. The plunger was either too low or there was too much water?

A. No, sir; not too much water. The true way is to have an ample supply of water if the plunger is set right.

290 271 x Q. The true way, in order to enable the engine to work properly, is that there should be a due proportion between the set of the plunger and the water in the cup?

A. The water may be anywhere in the dash-pot if the plunger is properly set.

272 x Q. Must there not be a due proportion of the set of the

plunger for the purpose of entering the cup and the water within the cup?

A. No, sir; the water should be entirely above the cup; and it may be five or six inches above it without affecting it. I told the engineers always to put more water in.

273 x Q. Did you not have to alter the set of the plunger in proportion to the water in the cup?

A. No, sir; if the engine was working properly with the dash-pot from $\frac{1}{3}$ to $\frac{2}{3}$ full, there would be no difficulty.

274 x Q. Is it of any consequence how much water is in the cup?

A. No consequence so long as it is above the top of the cup; it should be that much and how much farther above that is of no consequence.

275 x Q. You should be careful to keep it above the cup?

A. Yes.

276 x Q. Suppose it gets below, what is the consequence?

A. Then it commences to work on air with the water.

277 x Q. Then you have a difficulty?

A. Then they put a little more water in.

278 x Q. When it commences to work on air, in connection with water in the cup, do you find any difficulty in working the engine?

A. Yes, sir; if the plunger does not properly fit it.

279 x Q. I speak of your dash-pot.

A. When first made they will work on air without water, and work tolerably well.

280 x Q. Are they made to work on air?

A. No, sir.

281 x Q. You mentioned an experiment you made. You say the cup should be always full of water?

A. Yes, sir; above the cup.

282 x Q. In addition to that, the plunger should be set right also?

A. Yes, sir.

291 283 x Q. Then you have a good working dash-pot?

A. Yes.

284 x Q. But if the plunger is not set right, or the cup is not full, or the water does not overflow the cup, you have trouble in working the engines?

A. Yes, sir; unless you have a check ring on the valve. If you have a check ring on it, it does not require the same accuracy.

285 x Q. Then you are not so careful about the relation of the water to the cup if you have a check ring or slide valve?

A. No, sir.

286 x Q. The check ring must fit steam tight?

A. Yes, sir.

287 x Q. You mentioned some experiments you made with air in working one valve. On what boat was that?

A. On the steamboat *New Haven*.

288 x Q. That dash-pot was made to work with water?

A. Yes, sir; I made it first to work with air and afterwards to work with water.

289 x Q. When you made it to work on air what form did you give to the apparatus?

A. The plunger was perfectly straight, and so was the cylinder. When I made it to work on water I took out the plunger and rounded the bottom of it, so that it should not stop too suddenly.

290 x Q. You tried it on one valve?

A. I tried it on one valve before I got the other ready.

291 x Q. How long did you try it?

A Only about a week, while I was there.

292 x Q. And you discarded it; you did not like the operation?

A. I did not like to leave it that way. I was afraid they would not attend to it.

293 x Q. You discarded it?

A. I do not know exactly what the meaning of "discarded" is in reference to it.

294 x Q. You never made one to work that way after?

A. I never made them to work. I never saw one made to work with that intention. I have seen them working that way.

292 295 x Q. What was the form of the plunger then?

A. The plunger must have been round.

296 x Q. It was originally put in to work upon water?

A. Yes; but it worked on air.

297 x Q. Where did you see that, and when?

A. I have seen it on engines which were on board of the *Constitution* and the *George Washington*. They had large dash-pots, and would let the water get out of them, and they would work on air.

298 x Q. They were made to work on water?

A. They were designed to work on water.

299 x Q. What was the form of the plunger?

A. Round at the bottom and straight above.

300 x Q. When you found they would work on air you knew that they were tight enough for water?

A. Yes, sir; I knew they would be tight enough for water.

301 x Q. Did you not always ease them a little after getting them on the boat to work with water?

A. Yes, sir; when I found they did not work easy enough I made them a little looser.

302 x Q. This arrangement of Mr. Taylor he has got a patent for it?

A. Yes, sir; I believe so.

303 x Q. And got it extended a little while ago?

A. Yes, sir.

304 x Q. How did he arrange the use of his air pot or cushion?

A. He put a cylinder on to the frame of the machine and a plunger on to the bed, and, as the bed came in, it caught the air in the pot and compressed it.

305 x Q. Was that like your arrangement of the water dash-pot, in your judgment?

A. It had a means of moving freely through a portion of the stroke and then compressing the other portion.

306 x Q. Was that, in your judgment, like your water dash-pot?

A. I think it was in its operation.

307 x Q. I want to know if the apparatus was, in your judgment, substantially the same as your dash-pot?

293 A. No, sir; not in the combination on the printing press. I do not know that it was.

308 x Q. I believe you testified in the case of *Youngs & Cutter*, a case tried in New York?

A. Yes, sir.

309 x Q. Have any facts come to your knowledge since in reference to this dash-pot which you did not then state?

A. No, sir; nothing special that I know of.

Redirect.

310 Q. You recollect the time I bought the *Augusta?*

A. Yes, sir.

311 Q. Were you on board the boat when the engineer reported the condition of her engines to me?

A. Yes, sir.

312 Q. How was she reported to me?

[Objected to. Objection sustained.]

313 Q. Do you know how long before I bought the *Augusta* she had been put in order?

A. I think the engineer had been recently putting her in order.

314 Q. About the opening of valves. Do not all valves, slide or puppet valves, open quick enough after they get open to give steam?

A. Yes, sir; I think after they first open there is no difficulty.

315 Q. Did you ever see one that did not open quick enough?

A. I cannot say that I ever did see a steam valve that did not.

316 Q. When you use a puppet valve with a check ring upon it what is the effect on the necessity for accurate adjustment of the dash-pot?

A. It is not so necessary to have it perfectly adjusted. It compensates for the stupidity of engineers.

317 Q. In that respect is it the same as the slide valve?

A. Yes, sir. A more inefficient man can work it with less knowledge of the machine.

294 HENRY E. HOLLAND sworn.

Examined by Mr. Dickerson:

318 Q. What is your occupation?

A. Machinist and practical engineer.

319 Q. What is your present position and employment?

A. Chief engineer of the steamship *Coatyacoalcos.*

320 Q. How many years have you been engaged as machinist and engineer?

A. From my earliest youth. My father was a machinist, and I have been in the business all my days.

321 Q. Do you recollect the steamboat *Augusta* at the time I purchased her?

A. Yes, sir. I went on board of her about six months after you purchased her.

322 Q. Were you on that boat on the trial made to ascertain what she could do?

A. I was on the last occasion. I believe she went out on two previous occasions.

323 Q. How many turns were we able to get out of her a minute?

A. Sixteen was the highest number I saw got.

324 Q. What do you say about the condition of that engine, according to the standard of engineers in considering engines, in comparison with others?

A. Her condition was certainly not good, although claimed to be put so by the engineer previous to myself.

325 Q. State the condition without reference to what she had been before.

A. She was about as you find many of the boats on the river—in about the average condition that you find boats running on the river.

326 Q. That was when she was performing the sixteen revolutions a minute?

A. Yes, sir.

327 Q. Did you attend to putting her in order?

A. I did, sir.

328 Q. What was done with her?

A. I lined up the engine, made her piston tight, put in
295 new valves, and made them a little different shape on the face. I made them straighter on the face—as straight as they could well be made, without being liable to jam.

329 Q. These were puppet valves?

A. Yes, sir. We also made some difference in her lifting rods by cutting away the heels of the toes, so as to get the lead on the exhaust before the other valve would close.

330 Q. [By the court.] Repeat that.

A. We cut away the heels of the toes. The great object of this was that one exhaust valve should not close until the end of the stroke, which must necessarily be done with the common arrangement.

331 Q. What was the object of cutting the heels of the toes?

A. The greatest object was that one exhaust valve should not close by giving lead to the other. There was another advantage in cutting away the heels of the toes, which was that during the lifting of the exhaust valve there was an arrangement applied to raise the steam valve gradually and give the lead to the piston gradually, so as not to jar the engine and make it work more easily on the centres.

332 Q. After the engine was put in that condition was she tried over again?

A. Yes, sir.

333. What was the result?

A. The result was that, with the same steam, we got some twenty

three turns a minute—that is, the average turns. We made her run to twenty-seven or twenty-eight turns; but the average speed down the bay was about twenty-three turns.

334 Q. You took that boat out to Savannah?

A. I did.

335 Q. Last February?

A. In the middle of winter—in February.

336 Q. You were in a storm in her at sea in February?

A. Yes, sir; outside of the mouth of the Chesapeake.

337 Q. What was the effect of that arrangement on the engine in going through the storm?

A. The effect was that the engine would go to her centres
296 and work over her centres quite freely when the turns of the engine were reduced very low. Had the old arrangement been there, throwing the lead on the engine suddenly, the chance was that the engine would have stopped on the centres; she would have been thrown into a trough of the sea, and we would have lost the boat. But the engine continued to go along, and we eventually got safe into Chesapeake bay.

338 Q. Take any old arrangement you know of, of valve gear without that coexisting movement, what do you suppose would have been the effect there? Would it have stopped that engine on the centres?

A. Yes, sir; the lead of the exhaust would have left a certain portion of steam in the end of the cylinder, which, when compressed to the end of the stroke, would retard the motion of the piston; and when the engine was running very slow there was no momentum to perform the operation, and consequently the engine would stop on the centres. By cushioning the steam up at the end of the cylinder, the engine would stop on the centres, the boat would stop, and the probability is that we would have lost her. I have been frequently at sea in storms with much better arrangements than they have on a great many going to sea; I have had to stand by with the starting-bar to help the engine over the centers. After the exhaust-valve closed, the steam being cushioned up in the end of the cylinder, we required to open the exhaust valve and give steam on the opposite side.

339 Q. Single engines often catch on the centres at sea?

A. Yes, sir.

340 Q. Suppose she does catch and stop, what do you do?

A. You have to unhook and start her by hand again. In the mean time the vessel falls off into a trough of the sea and may get swamped.

341 Q. What was the condition of the *Augusta* at the time you were at sea? Was she a boat with guards on?

A. Yes, sir; about 160 ft. long; I suppose about 30 ft. beam, or hardly that—a small boat.

342 Q. Made for a North River boat?

A. Made for a river boat, sir.

297 343 Q. Have you been an engineer of a ship with the Sickles cut-off, before.

A. Yes, sir; I was on the steamship *Union*, with the Sickles cut-off.

344 Q. Tell the court with what you worked that cut-off—air, or water, or how?

A. In dash-pots which were supposed to carry water; but at various times it would give us trouble, wanting water, and I have lowered the plunger down in the dash-pot and worked with what I had no reason to suppose was anything but air.

345 Q. How would they work on air?

A. They would work very well, but rather more slowly than with water.

346 Q. What part of the time did you work with air, and what with water?

A. This working by air, I suppose, only took place at times—only for a short time, two or three hours at a time. I was only a subordinate engineer there, and when I came on watch, I would, instead of putting water in, lower the plunger down to the lower end of the chamber, and it would work very well that way.

347 Q. You were first assistant in the *Adriatic?*

A. Yes, sir.

348 Q. You recollect the Sickles cut-off there?

A. Yes, sir.

349 Q. You were there when the engine started?

A. When they first started the engine Mr. Sickles had made his plunger perfectly square on the end, and in trying it I attached a tackle and raised up and dropped the valve while there was nothing but air in the dash-pot. I found they would work very well, and gradually I lifted them up their full length and dropped the valve, and after adjusting it, I thought it worked so well that it would not be necessary to put any water in. I made that proposition to Mr. Allen and others at the Novelty Works—not to put water in; but they supposed, the dash-pots having been made for water, they should put water in them. They altered the shape of the bottom of the plunger, and did so.

350 Q. What was done on these plungers?

298 A. The ends were rounded off slightly.

351 Q. What was the effect of that?

A. The effect was that when the plunger struck the water in the chamber the water could gradually escape round the side, and let the valve come slowly to its seat.

352 Q. Was the plunger reduced in size?

A. No; the plunger was not reduced in size. It was rounded off on the edge.

353 Q. Have you an indicator card taken from the *Augusta?*

A. Yes, sir; (produces two.) These I took while the boat was running from Savannah.

354 Q. And they have been in your possession ever since?

A. Yes, sir; I took more. I sent some to you in a letter, and some to Mr. Sickles.

355 Q. That card is just as the engine made it?

A. Yes, sir; it has never been touched.

356 Q. The scale and indicator is here?

A. Yes, sir.

357 Q. Were these the best cards you had, or how did you come to have these now?

A. There were some I considered not so good as others I had taken. They were left after I selected the best cards. Some I gave away to different machinists.

358 Q. These were the refuse you had left?

A. Yes—the only two I had left.

359 Q. Is there an arrangement on that engine for slowing the steam valve in opening?

A. Yes, sir; loss of motion on the lifting rods to let the steam gradually on to the engines.

Cross-examined by Mr. Stoughton.

360 x Q. I understood you to say, when interrupted, that although the report of the engineer of that boat was that her engine was in very good order, yet you found her not in good order at the time Mr. Dickerson obtained her?

A. Yes, sir; I said so.

361 x Q. When you say that her engines were in about the
299 average order of engines running about the bay, what do you mean?

A. I mean that they were in such order that people who owned them either could not afford it, or did not feel disposed to put them in that order we put the *Augusta* in.

362 x Q. Such as an engineer would call good order?

A. The men running those boats do not receive very good wages, and they are not men who know if an engine be in good order.

363 x Q. You thought the engine was in bad order?

A. Yes, sir.

364 x Q. I want to get your statement precisely about the effect of changing the form of the toes. Do I understand the object of that was to enable you to commence the opening of one exhaust before the other exhaust valve was closed?

A. Exactly. Both the exhaust valves were open when the toes were down on the lifters.

365 x Q. And the purpose was to commence the opening of one exhaust valve before the other exhaust valve should be closed?

A. Yes, sir.

366 x Q. Was that accomplished by this change?

A. Yes, sir; that was accomplished.

367 x Q. Was anything else accomplished but that by the particular change to which you refer?

A. There was. There was motion enough in the rod that had been dropped, or was about dropping, to place a motion between the lifter and the valve, which gradually opened the steam valve. No engineer but will admit that is essentially necessary.

368 x Q. I wish to know what that particular change enables you to do with the valve. You say it enables you to commence opening

344 Q. Tell the court with what you worked that cut-off—air, or water, or how?

A. In dash-pots which were supposed to carry water; but at various times it would give us trouble, wanting water, and I have lowered the plunger down in the dash-pot and worked with what I had no reason to suppose was anything but air.

345 Q. How would they work on air?

A. They would work very well, but rather more slowly than with water.

346 Q. What part of the time did you work with air, and what with water?

A. This working by air, I suppose, only took place at times—only for a short time, two or three hours at a time. I was only a subordinate engineer there, and when I came on watch, I would, instead of putting water in, lower the plunger down to the lower end of the chamber, and it would work very well that way.

347 Q. You were first assistant in the *Adriatic?*

A. Yes, sir.

348 Q. You recollect the Sickles cut-off there?

A. Yes, sir.

349 Q. You were there when the engine started?

A. When they first started the engine Mr. Sickles had made his plunger perfectly square on the end, and in trying it I attached a tackle and raised up and dropped the valve while there was nothing but air in the dash-pot. I found they would work very well, and gradually I lifted them up their full length and dropped the valve, and after adjusting it, I thought it worked so well that it would not be necessary to put any water in. I made that proposition to Mr. Allen and others at the Novelty Works—not to put water in; but they supposed, the dash-pots having been made for water, they should put water in them. They altered the shape of the bottom of the plunger, and did so.

350 Q. What was done on these plungers?

298 A. The ends were rounded off slightly.

351 Q. What was the effect of that?

A. The effect was that when the plunger struck the water in the chamber the water could gradually escape round the side, and let the valve come slowly to its seat.

352 Q. Was the plunger reduced in size?

A. No; the plunger was not reduced in size. It was rounded off on the edge.

353 Q. Have you an indicator card taken from the *Augusta?*

A. Yes, sir; (produces two.) These I took while the boat was running from Savannah.

354 Q. And they have been in your possession ever since?

A. Yes, sir; I took more. I sent some to you in a letter, and some to Mr. Sickles.

355 Q. That card is just as the engine made it?

A. Yes, sir; it has never been touched.

356 Q. The scale and indicator is here?

A. Yes, sir.

357 Q. Were these the best cards you had, or how did you come to have these now?

A. There were some I considered not so good as others I had taken. They were left after I selected the best cards. Some I gave away to different machinists.

358 Q. These were the refuse you had left?

A. Yes—the only two I had left.

359 Q. Is there an arrangement on that engine for slowing the steam valve in opening?

A. Yes, sir; loss of motion on the lifting rods to let the steam gradually on to the engines.

Cross-examined by Mr. Stoughton.

360 x Q. I understood you to say, when interrupted, that although the report of the engineer of that boat was that her engine was in very good order, yet you found her not in good order at the time Mr. Dickerson obtained her?

A. Yes, sir; I said so.

361 x Q. When you say that her engines were in about the
299 average order of engines running about the bay, what do you mean?

A. I mean that they were in such order that people who owned them either could not afford it, or did not feel disposed to put them in that order we put the *Augusta* in.

362 x Q. Such as an engineer would call good order?

A. The men running those boats do not receive very good wages, and they are not men who know if an engine be in good order.

363 x Q. You thought the engine was in bad order?

A. Yes, sir.

364 x Q. I want to get your statement precisely about the effect of changing the form of the toes. Do I understand the object of that was to enable you to commence the opening of one exhaust before the other exhaust valve was closed?

A. Exactly. Both the exhaust valves were open when the toes were down on the lifters.

365 x Q. And the purpose was to commence the opening of one exhaust valve before the other exhaust valve should be closed?

A. Yes, sir.

366 x Q. Was that accomplished by this change?

A. Yes, sir; that was accomplished.

367 x Q. Was anything else accomplished but that by the particular change to which you refer?

A. There was. There was motion enough in the rod that had been dropped, or was about dropping, to place a motion between the lifter and the valve, which gradually opened the steam valve. No engineer but will admit that is essentially necessary.

368 x Q. I wish to know what that particular change enables you to do with the valve. You say it enables you to commence opening

one exhaust before the other is closed. What operation did it have on each of the steam valves?

A. It had the operation that the steam valve did not lift until after the exhaust valve had got the necessary lead. More than that, when the steam valve did commence to lift, it permitted a motion between the lifting and exhaust valve, and the lifting and steam valve, which gradually raised the steam valve at the proper time.

300 369 x Q. Do I understand you to mean that you gave a considerable slack between the valve and the shoulder by which it was lifted?

A. Yes, sir; 1½ inches.

370 x Q. So that, inasmuch as the steam valve would not commence to lift until the slack had been taken up, your exhaust valve would be moving on some time?

A. Yes, sir; exactly.

371 x Q. You had no lap to your valve?

A. No, sir.

372 x Q. You did not overcome any?

A. No, sir; but we overcame many other things. There is another advantage to slack or lost motion, as you term it. After we get the steam valve fairly started we get the toe up to the end, which is the best mode to open quick; then that is the best part of the toe to get full boiler pressure on the engine.

373 x Q. The object is to get full boiler pressure on to prevent wire-drawing?

A. Yes; but we want to have it gradually first.

374 x Q. You do not mean to say that you can commence opening the steam valve before it strikes the shoulder to start it?

A. Yes, sir; there is a lever with a short fulcrum. There is the lifting or drop toe, which is placed between the lifter and the catch which lifts the valve. The fulcrum is adjustible, so that if the engineer at any time wants to get more lead, he can adjust that.

375 x Q. You do not find that in either of these models?

A. No, sir.

376 x Court: You refer to an additional instrument to the shoulder of the lifter that raises the valve before the shoulder of the lifter is reached?

A. Yes, sir; exactly.

377 x Q. And thus you interpose an instrument, before the slack is all taken up, for the purpose of starting the steam valve?

A. Yes, sir.

378 x Q. That, I understand, is to let the steam on gradually at first?

A. Yes, sir.

301 By Mr. Stoughton:

379 x Q. Do you think that very important?

A. Yes, sir; so far as the working of the engine is concerned.

380 x Q. Do you think that instrument is what saved your life in the storm?

A. Not that altogether, but the general arrangement of the valves.

381 x Q. Do you suppose that without that little instrument you would have been saved?

A. I suppose if the boat was in such a condition that she would stop on her centres, we would have been lost.

382 x Q. What is the effect of that little arrangement on the safety of the engine preventing friction?

A. To prevent a jar on the engine.

383 x Q. Is it a very important arrangement?

A. I consider it, on large engines, a very important thing that the steam valve should be opened slowly to let on the steam gradually at the beginning of the stroke, and after the valve is thrown open, the quicker you get boiler pressure on the better.

384 x Q. By this arrangement did you let steam into the cylinder a little before your piston got down, or not until after the piston commenced going back?

A. We let it in before the piston got to the end of its stroke by this means.

385 x Q. Instead of beginning to let it in after the piston has got down to the dead point, or after it commenced to go back?

A. Yes, sir.

386 x Q. Which must have had a tendency to check the piston in going home?

A. Exactly so. That we consider among engineers as of very great importance, leading steam on to the engine, or giving the engine lead. It is a choice between two evils, and something that cannot be arrived at, except practically. A man to go to work and say, I will give this engine so much lead, he cannot arrive at any practical point of lead: but when he gets running, the faster the engine runs, the more lead it requires.

302 387 x Q. Tell us how many revolutions the engine of the *Augusta* was making when she made that card.

A. About 20 revolutions. Her steam was not as high as she usually carried it. I should not judge we had more than 25 lbs.

388 x Q. What vessel do you say you were on when you first used the dash-pot, without water, from time to time?

A. The steamship *Union*, in the summer of 1855.

389 x. Q. That was the first time you had occasion to use them?

A. That was the first time.

890 x Q. And when did you think of trying to use the dash-pot with air, on the *Adriatic?*

A. Well, it was about 3 or 4 weeks before the *Adriatic* went to sea—within two years.

391 x Q. Your suggestion was not adopted there, was it?

A. No, sir.

392 x Q. The dash-pot you used on the *Union*, did you have charge of the keeping of water in it?

A. No, sir. I was only assistant engineer. It was part of my duty, 8 hours out of the 24, to see there was water in it.

393 x Q. Was that part of the duty that devolved upon you?

A. Yes, sir.

394 x Q. But sometimes you think you let it run without any water?

A. Yes, sir.

Redirect.

395 Q. How much steam did you have on the engine of the *Augusta* when making that card by the scale?

A. 29 ibs. [Looking at scale.]

296 Q. Is that the indicator from which you took it?

A. That is the one, sir.

397 Q. Do you recollect what we did with the lead on the eccentric before the *Augusta* went to sea—whether we took the lead off, or what?

303 A. We put more lead on gradually on the eccentric, and we got the lifter so that the exhaust valve would stay open until almost the completion of the end of the stroke. After I got to sea I altered the lead on the steam valve.

398 x. [By Mr. Stoughton.] Do I understand you to say you see or do not see upon model 3 any means by which you can impart a slow lifting motion to the steam valve at the time it commences to open—like what you called your lever?

A. Not mechanically like that.

399 x Q. Do you see any means there developed substantially to accomplish the same thing?

A. Yes, sir, to accomplish the same thing.

400 x Q. That is, to open the steam valve very slowly at the commencement of the stroke?

A. Yes, sir.

401 x Q. Does the steam valve open until the shoulder of the lifting rod is struck by the catch that rises to open it?

A. No, sir; it does not lift until then.

402 x Q. Was not the purpose of the little instrument of which you spoke to cause the valve to open slowly before the shoulder struck?

A. To cause the steam valve to open slowly.

403 x Q. Do you find in that model any means to cause the steam valve to open slowly before the shoulder strikes?

A. Not before the shoulder strikes.

404. [By Mr. Dickerson.] In either case can the steam valve open until the shoulder strikes?

A. No, sir.

Court: According to the witness's account there was an instrument here interposed, on the *Augusta*, that raised this latch up to the shoulder, and started the steam valve before the shoulder was reached by the more rapid motion of the lifter. That was the idea I got.

Mr. Dickerson: The word "shoulder" was improperly used.

405. On the *Augusta* is there any means of lifting the valve except this shoulder?

304 A. No other means.

406 Q. That valve is not lifted by any other means?

A. No.

407 Court: But then there was a means that raised this latch to the shoulder?

A. It raises the latch and not the valve.

408 Q. Until it strikes the shoulder, which raises the valve?

A. Yes, sir.

By Mr. Stoughton:

409 x Q. Do I understand you to say the toes which are there [model 3,] are shaped differently from the engine of the *Augusta?*

A. These toes are shaped somewhat differently, being a little more rounded on the heel.

410 x Q. That is all the difference?

A. That is all.

411 x Q. As I understand you, an engine constructed like that model, with a latch coming up and striking the shoulder, would lift the steam valve more suddenly than it was lifted by the interposition of the lever of which you spoke. Is that what you mean?

A. No.

412 x Q. Do you mean to say that the steam valve in a model like that is lifted just as slowly as that was in the *Augusta?*

A. Nearly so. It might be made to do so by a proper shaping of the toes.

413 x Q. I speak of that model as there seen?

A. As near as I can judge, it would.

414 x Q. You think when that comes up against the shoulder, there would be no sudden lift any more than on the *Augusta?*

A. I think not.

415 x by Mr. Curtis: I understand the effect to be produced on the model, by the shape of the toes—by the rounding of the toes—is to move the steam valve slowly?

A. Yes, sir.

305 416 x Q. In the means you resorted to, you interposed a lever for that purpose—the toes not being in the shape of that model?

A. The toes were the proper shape.

417 x Q. It was another means to produce the same effect as altering the shape of the toes?

A. Substantially the same.

418 x Court: Mr. Dickerson has explained that in this model, by the alteration of the toes, on the rounding of them, it operated to raise the lifter of the exhaust valve more rapidly—to exhaust the steam more rapidly. It also, in some way which I do not comprehend, answers the same purpose of your former contrivance—to open the steam valve gradually at first, so as to let in the steam more slowly. Explain that.

A. [Pointing out on model.] In this case, these lifters are made to work the steam valve with slow motion at first. These toes are made to work the steam valve properly.

NOBLE T. GREEN was called by the defendant.

Mr. Thurston said he proposed by Mr. Green, not to antedate the

invention of Mr. Corliss, but to offer proof in correspondence with the answer, which set out that Mr. Green made the invention patented by himself in good faith, and, in point of fact, long before.

Mr. Curtis objected to the examination of Mr. Green, on the ground that he was interested in the suit.

Mr. Thurston thought he had no interest which would legally disqualify him.

Mr. GREEN was sworn, and *examined* by Mr. Curtis, as to his interest.

419 Q. You sold the engines to the Wheeler & Wilson Manufacturing Company?

A. No, sir. The engines were manufactured by the Pacific
306 Iron-Works, in Bridgeport. The contract was made between Wheeler & Wilson Manufacturing Company and the Pacific Iron-Works.

420 Q. What contract did you have with the Pacific Iron-Works, or Wheeler & Wilson?

A. I have a contract with the Pacific Iron-Works that they pay me so much on the machines they make.

421 Q. Have you not agreed with the Pacific Iron-Works Company, or Wheeler & Wilson, that you would defend them against Mr. Corliss' patent?

A. I have an agreement with the Pacific Iron-Works Company, that I would defend them against *any* patent; not particularly this, more than any one else.

422 Q. Have you employed counsel in this suit?

A. I have.

423 Q. For the purpose of defending it?

A. Yes.

424 Q. Your obligation extends to all expenses of the defence in the suit?

A. I suppose so.

By Mr. Thurston:

425 Q. Is there any other agreement than a mere statement, on your part, of your willingness to do it?

A. I told them that I would hold them harmless—the Pacific Iron-Works Company.

426 Q. Have you guaranteed Wheeler & Wilson to defend them?

A. I would not be positive. I gave Mr. Skidmore, I think, two or three indemnities. I will not be positive whether the Wheeler & Wilson Manufacturing Company was one of them. Mr. Skidmore is treasurer of the Pacific Iron-Works.

427 Q. But you have not had any contract with Wheeler & Wilson at all?

A. No, sir.

428 Court: Have you agreed to defend this suit?

A. I have made no agreement with Wheeler & Wilson Manufacturing Company, any further than that I went there and showed
307 them the answer in this case, as I was required to do. The

indemnity I gave Mr. Skidmore was for two or three parties; but whether one of these indemnities was for Wheeler & Wilson Manufacturing Company I do not know.

By Mr. Curtis:

429 Q. When you heard this suit was to be brought, you undertook the defence?

A. I did.

430 Q. Why did you do so?

A. I did so to defend my own patent.

431 Q. Did you not do so because you made some agreement with some one?

A. Not solely on that account.

432 Q. But for that and other reasons?

A. It was done for the defence of my rights, on my patent principally—only.

433 Q. Only?

A. Yes, sir; I do not know that the idea entered my head that I was under an engagement or necessity for doing it.

434 Q. Do you not understand that you made an agreement which requires you to defend this suit?

A. I understand this: that I was bound to defend this suit.

435 Q. Are you here defending it?

A. Yes, sir.

Court: That, of course, would exclude the witness, unless there is a release.

HENRY B. BEACH sworn.

Examined by Mr. Dickerson:

436 Q. You are one of the firm of Woodruff & Beach?

A. Yes, sir. The company is the Woodruff & Beach Iron Works.

437 Q. You are treasurer of that company?

A. Yes, sir.

308 438 Q. Inform the court what kind of engines you have been manufacturing for the last half dozen years, so far as the connection of the regulator and cut-off is concerned.

A. We have made a variety of kinds, principally Wright's cam cut-off with the puppet valve.

439 Q. Did you hear Mr. Wright examined the other day?

A. No, sir.

440 Q. How is the regulator attached?

A. Attached to the cut-off.

441 Q. Have you made a large number of those engines?

A. Somewhere between fifty and one hundred of that kind.

442 Q. Are any running in this town?

A. About a dozen, I think.

443 Q. The regulator attached to what?

A. To the cam cut-off.

444 Q. Do you know what is the construction of that cam—the first one you made, and those subsequently?

A. I am not mechanic enough to give the technical terms. I am no mechanic myself. The first cam that we used is what we call the French cam; that is, as I was told. The one we now use is a double cam worked with a groove or spline.

445 Q. What Mr. Wright called the expanding cam?

A. Yes, sir.

446 Q. How do those engines regulate as to speed?

A. Very uniformly, indeed. They have always given good satisfaction.

447 Q. Have you ever had any difficulty about it?

A. No, sir; they regulate perfectly, I believe.

448 Q. What is the class of mills and machinery to which they are applied? Is it such as requires accurate regulation?

A. Yes, sir; woolen-mills, saw-mills, rolling-mills, almost every kind. In a carpet company, where we have one, they are obliged to regulate it to half a revolution a minute.

449 Q. Have you got it on a silk-mill here?

A. Yes, sir; there are two of them now in silk-mills in this city.

309 450 Q. Are you building that kind now?

A. Yes, sir; all of them.

451 Q. Have you been threatened with a suit about them?

A. Our customers have been told, sometimes, by Mr. Corliss that he was going to sue them when he wanted to sell engines very badly.

452 Q. Have you taken out other engines and put in these, sir?

A. Yes, sir; in several instances.

453 Q. With what effect?

A. Always with good results in every instance.

454 Q. What do you mean by good results?

A. We lessened the consumption of coal.

455 Q. Are there any cases where you know the quantity of saving?

A. I do not know that I can bring it to mind now without my books.

The court intimated that this was irrelevant. While the defendant was at liberty to put in any proof with reference to the French machine, he could not combine a modern improvement with it and from that argue want of novelty in the plaintiff or want of infringement by the defendant.

456 Q. How did the cam made—the French cam—operate?

A. Very well.

457 Q. Is it running yet?

A. I do not know; the company failed and it changed hands, but I believe it is running. I know it ran for several years, and very satisfactorily indeed.

Mr. Thurston claimed that if the plaintiff took the ground that the French machine was not an operating machine, the defendant would have a right to produce the witness to prove that the Woodruff & Beach machine worked perfectly.

310 Mr. Curtiss objected that the defendant should now exhaust their evidence.

The court so ruled under the circumstances of this case.

By Mr. Stoughton:

458 Q. Do I understand you to say you recollect the mode in which that engine was constructed, which you made seven years ago, without an expanding cam?

A. No, sir; I have an idea of how it was made. I know it was worked by a cam, which was called a French cam. The cam was tapering and spiral, very similar to *this*, as I understand it, (refers to French machine.)

Adjourned to 2 o'clock.

AFTERNOON SESSION.

At the reassembling of the court (2 o'clock) Mr. Keller stated that there was one fact in the case which he knew of only two persons that could prove—one, Mr. Richard M. Hoe, of New York, whom he intended to call; and the other, Mr. Edward Dickerson, who declined testifying. But he had received a telegraphic dispatch from Mr. Hoe stating that he was sick and could not come; he had met with an accident, breaking his leg some time ago, and was not well since. Under these circumstances they had urged Mr. Dickerson to testify, and he consented to do so. He deemed it due to Mr. Dickerson to say that he had not been counsel in any of the cases, as respected this particular engine, and had been called in in this case, because he happened to be waiting for another.

EDWARD N. DICKERSON sworn.

Examined by Mr. Keller:

459 Q. Are you acquainted with the publication describing
311 the engine, represented by the model, called the French engine?

A. Yes, sir; perfectly well.

460 Q. When did you first become acquainted with this publication?

A. If my recollection of dates be correct, it was in the year 1851 or 1852. I cannot now say which. Mr. Corliss brought a suit against an engine having the Sickles cut-off, with a governor attached to it, and I was the counsel for the defendant in the trial of that cause. It was the case of *Corliss* v. *Gorham*, which I find referred to in these pleadings. It was tried at Newport, R. I., at that time. On that occasion the French machine, as it is called, was one of the facts given in evidence by the defendant, and the subject of testimony by experts, Mr. Waters, and other gentlemen there on that occasion.

461 Q. Have you since that, at any time, and if so when and where, seen one of those engines, built in accordance with the published description in use?

A. Yes, sir; in the year 1854 I was in Europe, where I was engaged in a matter connected with engineering, and I investigated there all the engines I could. I made it my business to examine all the engines with a view to ascertaining the state of engineering in

France and England. I was at that time engaged in engineering myself. Since about that time I have been engaged in engineering operations, and not in law, except in some particular cases in which I had an interest, or had been formerly connected with. I was there examining the whole of the matter as far as I could; and while there, among other things, having this machine in my mind, and the knowledge of what had been testified about it, I went to examine it.

462 Q. What was the engine doing, what was about its capacity, and how did it work?

A. It was in the city of Paris. I did not measure the size of the engine. My recollection about it is, that it was about two twenty-four-inch cylinders and four or five feet stroke.

463 Q. State what kind of work it was doing.

A. It was running a paper-mill in the city of Paris, making fine paper, and there were a good many machines connected with
312 the paper-mill, cutting machines and calendars, and such machinery as is common in a paper-mill.

464 Q. State what you mean by fine paper.

A. I speak of a very thin light paper, known as French paper. I bought some of the paper there, at all events.

465 Q. Was the paper formed by hand or on a machine?

A. On a machine—Foudrinier's.

466 Q. State whether the making of that kind of paper on the Foudrinier machine requires accuracy of movement and steady motion, or whether it can be done with unsteady motion.

A. It is a manufactory that requires very steady motion. I have been consulted, as engineer, about producing that steady motion in paper-mills in this country, and I know the problem very well. The reason is, that a Foudrinier machine runs out the paper by distributing or pouring out pulp on an endless wire gauze that runs underneath it which drains out the water, and that runs at a certain speed. There is a spout out of which is poured upon a wire cloth a triturated pulp which makes the paper; that is delivered in a constant quantity from an aperture of a given size. If the wire gauze varied in its speed, the spout would, consequently, pour more paper in a foot upon it at one time than at another, and the paper would be thicker at one time than another; therefore the necessity that the sheet should move with as much uniformity as possible.

467 Q. Is that more necessary for certain kinds of paper than for other kinds?

A. I should say that in making fine paper it was of greater importance than in coarse paper.

468 Q. From the examination you made, how did you find it to operate and regulate?

A. It was running with great regularity and perfection. That fact I reported to those gentlemen when I came home.

469 Q. What kind of governor had it?

A. It had a mill-governor. This arrangement of the machine, as represented on this model, [French models,] I cannot say, now,
313 whether the two cogs were left, or whether the pauls worked

between on a clutch, one on the other. My attention was not called to that.

470 Q. I wish to know whether the governor was directly connected to the cam, or whether it started a screw or sector, as on the model?

A. It ran on a screw, as that is. My attention was not called to any such question as to whether it was driven by a clutch, or whether the cogs were themselves a clutch.

471 Q. Would that make any difference in the machine?

A. No; both would be the same machine. So far as that is concerned, it is a mere question as to the range of motion. I would like to say to the court, in regard to this matter, that of course it is very disagreeable to me to be called as a witness. I had no idea of what this case was about when I came here; but as I had to remain, and out of regard to Mr. Green, I consented to take his part. But, then, Mr. Hoe would state the same facts. I would also say, that at the trial at Newport there was no pretence of this kind that the governor would not regulate. The pretence there was that the cam would not work, because there was such a friction upon it.

Cross-examined by Mr. Stoughton.

472 x Q. Do you recollect at whose establishment you saw this machine?

A. I cannot tell the name. It was a large paper concern.

473 x Q. In what part of Paris was it?

A. I cannot tell you; I cannot tell the street. It was a street that leads from the *Port St. Denis* over to the *Boulevard d'Italien.* I think I could go to the place again. I have no doubt you could find many of them running.

474 x Q. Why do you state that you have no doubt you could find many of them running?

A. Because I have heard from Mr. Hoe that he has seen several.

475 x Q. Did you not say, yesterday, that a great number were running in Hartford?

314 A. I said that a great number of a certain kind of machines testified to here were running in Hartford.

476 x Q. Did you not state here that a number of machines, which you called the French machines, were running in Hartford?

A. I think not. My recollection of what I meant to state, and I have no doubt what I did state, was, that a great number of those machines Mr. Wright had described were running in Hartford—the same machines as that.

477 x Q. Did you not state, before Mr. Wright was examined, that a number of that kind of machines were running in Hartford?

A. Not that I recollect.

478 x Q. I would ask whether the machine you saw in Paris was as near like that, in its detail and in all its parts, as you understand the machine described by the witness yesterday to be?

A. Which machine do you refer to?

479 x Q. I want to know whether the machine you saw in Paris

was constructed as near like that model as you understand the machines constructed here in Hartford are like that?

A. Certainly. The machine in Paris had a mill-governor, and was more than like this. The machines here have a common fly-ball governor in them.

480 x Q. With none of that intermediate machinery between the governor and the cam?

A. There is no intermediate machinery between the governor and the cam here.

481 x Q. Do you think it makes any difference in respect to regulation whether *that* is on or not?

A. No; this machine will regulate more perfectly than a fly-ball governor.

482 x Q. I mean the intermediate machinery between the sleeve of the governor and the cam?

A. This whole organization is a governor. This gearing and balls constitute what is known in mechanics as a governor.

483 x Q. You mean to say that by the use of machinery between the sleeve of the governor and the cam you are better able to regulate a steam-engine, in your judgment, than as by the machines of Woodruff & Beach?

315

A. If you want a very perfect and precise regulation, to reduce the regulation to a nicety, this machine will do it better than a fly-ball governor. If you want a regulation, in which one or two turns a minute are of no consequence, then the other is a cheaper, more convenient, less delicate machine, and more generally adopted.

484 x Q. I consider you to say, in your judgment, that was a better regulation?

A. I told you in what respect I made it a better regulation.

485 x Q. Now, I want to know if you examined the machine in Paris in reference to its regulation.

A. I certainly did, sir.

486 x Q. So as to be certain it corresponded in all its details, including cog-wheels, screw and all, with that before you?

A. Now you are asking me a little too much. I cannot say *these* two bevel-wheels were put in that position.

487 x Q. Can you say they were there?

A. Undoubtedly they were.

488 x Q. You are sure of that?

A. I am; *this* might have been a plain wheel.

489 x Q. Are you sure the cam was screwed along that way?

A. Yes, sir; that was the way it regulated.

490 x Q. And you never saw any other machine than that regulate in that way?

A. I never saw one like this machine, except that once.

491 x Q. Did you ever see a machine arranged for regulation in that way, except in Paris?

A. If you mean the whole machine together, I never have; if you mean the manner of regulation, I have a good many.

492 x Q. What do you include in the regulator?

A. I include the regulator itself; these two balls, and the gearing by which the motion backward and forward is communicated to the work to be done.

493 x Q. Do I understand you to say that you have seen a
316 steam-engine elsewhere than in Paris constructed substantially like that in the parts that go to make up regulation?

A. Connected with the throttle valve—yes, sir.

494 x Q. I mean connected with the steam valve?

A. I never saw a mill-governor connected with the steam valves, except the one in Paris. I do not think I have.

495 x Q. Have you seen any steam-engines in England?

A. Yes, sir. I have seen a great many in England, and studied the question thoroughly.

496 x Q. Do you know where that French engine is described?

A. I do, sir.

497 x Q. How long have you known the book in which it is described?

A. I have known the book a long time.

498 x Q. Some ten years?

A. More than that. I have been in the habit of reading these publications. I was educated for an engineer.

499 x Q. Was that machine described, to your knowledge so described, ten years ago?

A. That is a question of dates. I cannot say. I think the first time I knew the machine was at the Newport trial, in 1851 or 1852.

500 x Q. You were then satisfied it was a perfect mode of regulation by looking at it?

A. Yes; because I knew this mill-governor was a perfect mode of regulation.

501 x Q. Have you built, or advised the building, of any machines since you were in Newport?

A. Yes, a great many.

502 x Q. Did you ever put on such a regulator as that for the purpose of cutting off?

A. Without the gearing—leaving that out—I have, upon the same mode of operation.

503 x Q. Leave in that gearing?

A. I have made some with the same mode of operation, but not with that same instrumentality.

504 x Q. I want to know have you ever made a steam-engine, with a mode of regulation, including the mode of screwing along the cam, that operates the screw valve, like that?

317 A. No, sir; not screwing it along. I never put a mill-governor on an engine in my life.

505 x Q. How happened it that you never put on one if you thought they were so much more perfect than any others?

A. Because I know a better one.

506 x Q. How long have you known it? Since Corliss' invention?

A. No; Corliss never came near that. I have known it a good many years.

507 x Q. Where is that to be found?

A. If you go to the establishment of Henry A. Burr, hat manufacturer, in the city of New York, you will see one.

508 x Q. When was that put up?

A. If my recollection be right, 4 or 5 years ago. It is a Sickels cut-off. The governor does not regulate, though.

509 x Q. What kind of a governor do you use?

A. That is what I will be very glad to tell you. A fly-ball governor is used to put in action the power of the Croton; the power of the Croton regulates the engine. It is the most perfect regulation I ever saw, I think. It is a thing Mr. Sickles invented several years ago.

510 x Q. Has that mode of regulation been kept a secret?

A. No, sir; it has been running there a number of years.

511 x Q. On that one engine alone?

A. No. I made it for another. It was also made for one in Providence.

512 x Q. Where is that one?

A. It was taken down, and ought to be, for it did not work well.

513 x Q. One of Corliss' was put in place of it?

A. I do not know.

By Mr. Keller:

514 Q. State whether the engine you saw in Paris had a helical cam?

A. Yes, exactly like that.

318 By Mr. Stoughton:

515 x Q. How long were you looking at the engine in Paris?

A. I was in the mill probably an hour or so.

516 x Q. Including your examination of all the mill and machinery? That is all the time you examined it?

A. That is all. I did not think it worth while to examine it more than once.

HORACE C. BURGESS sworn.

Examined by Mr. Thurston:

517 Q. Were you formerly an engineer in any establishment in the neighborhood of Providence?

A. I was engineer in the Atlantic Delaine Mills.

518 Q. You had a double cylinder engine?

A. Yes, sir.

519 Q. Put in by General James?

A. Yes, sir.

520 Q. How long a time were you engineer?

A. From the time they started until the engine was taken out—about 1½ years.

521 Q. Beginning when?

A. Some time in the year 1851 I commenced.

522 Q. While you were engineer of that mill was there any con-

troversy going on between Mr. Corliss and any other parties relative to infringement of letters patent?

A. I think there was.

523 Q. That being fixed, I ask whether you made any experiment at the direction of any parties in the running of that engine, and if so, what they were?

A. We applied the regulator to the swipe-rod or steam cut-off, and again we applied it to the throttle valve. I think we tried it for a week each way.

524 Q. What kind of cut-off was that engine provided with?

A. Sickles'.

525 Q. It had also a throttle valve, you say?

A. Yes.

319 526 Q. When you attached the governor to the cut-off, to what did you attach the slide of the governor?

A. I attached it to the stem of the valve.

527 Q. To the stop that trips the valve?

A. Yes, sir; to the swipe-rod.

528 Q. When you attached the governor to the throttle valve, to what did you attach it?

A. To the arm of the valve direct, on the outside.

529 Q. Do you mean the crank upon which my finger is?

A. Yes.

530 Q. You tried each experiment a week?

A. Yes, sir.

531 Q. What description of throttle valve was used in this engine?

A. What is commonly called a register valve.

532 Q. What did the result of these experiments indicate, with reference to the economy of the attachment, in the two cases?

A. Well, the difference between applying the regulator to the cut-off and to the register valve was very small indeed. I could not give the exact figures; it being some 9 or 10 years since. The difference was small, something less than 200 lbs. of coal in a week; so small that we kept the regulator applied to the register valve afterwards, while those engines ran.

533 Q. Did you have the figures at one time?

A. We did, sir.

534 Q. Did you testify on this matter before?

A. I did, at Newport.

535 Q. Did you hand the figures then to any one?

A. Yes, sir; I think I gave the figures to General James, and have not seen them since.

536 Q. And you continued the attachment of the regulator to the throttle valve?

A. Yes, sir; while the engine ran.

537 Q. In the matter of regulation, how was it in both instances?

A. It was full as good attached to the throttle valve as to the trip or swipe-rod. The mill required a certain speed, and we got it either way.

320 538 Q. You say there was only 200 lbs. difference in the

course of a week. What percentage was that of the amount of fuel consumed?

A. Probably not more than one per cent. We burned 3½ or 4 tons a day.

Cross-examined by Mr. Stoughton.

539 x Q. Who put this engine in?

A. Thurston, Green & Co.

540 x Q. They were licensees of Sickles?

A. I think they were at that time.

541 x Q. About how long after the engine was put in was it before this experiment was made of attaching the governor to the trip puppet valve?

A. I think it was applied about the time the engine started.

542 x Q. Who applied it, or under whose directions was it applied?

A. I cannot say whether General James' or Thurston & Green's.

543 x Q. When did it first start?

A. In 1851, I think.

544 x Q. You do not know whether the attempt to connect the governor with the puppet valve was made by Mr. James or by Thurston, Green & Co.?

A. I presume the engine was built by Thurston, Green & Co., and so arranged as to apply the regulator either way—either to the throttle valve or the other way.

545 x Q. And you gave the preference to the register valve at the time?

A. I did at the time.

546 x Q. Was that because the register valve, acting as a throttle valve, wire-drew the steam?

A. No, sir; there was but very little wire-drawing any way. The valve was applied very close to the steam valve; it had no chance to wire-draw.

547 x Q. You think, regulating by that, you were not obliged to wire-draw with a fixed cut-off?

A. Very probably we wire-drew some, of course.

548 x Q. At what part of the stroke did you cut off?

321 A. ¼th, I think.

549 x Q. Did you use or attempt to use that mode of regulation to the steam puppet valves more than a week?

A. Oh, yes, sir; we applied it a long time both ways. When we tried the experiment to test the question we weighed our coal each week.

550 x Q. Why were you testing the question at that time?

A. We wanted to know whether it was cheaper to run one way than another.

551 x Q. Was that Thurston & Green's purpose?

A. I cannot say.

552 x Q. You say they applied that?

A. They built the machine.

553 x Q. How many tons did you use?

A. I think we burned about $3\frac{1}{2}$ tons a day.

554 x Q. Did you consider that a good engine?

A. The engine was very good, sir. There was one difficulty—the engines settled. The foundations were poor.

555 x Q. Were the foundations repaired and the same engines put back running again?

A. The engines were not taken out then; they were repaired.

556 x Q. Did you find any difference in the working?

A. They worked better than when they were out of line, but they settled again.

557 x Q. Were they not good engines?

A. Yes, sir; the only difficulty was that they were too large for the mill.

558 x Q. Could you not work with one?

A. We could, but we did not think they would work so well as together. They were cross-head engines.

Redirect.

559 Q. I understand you to say they were out of line when repaired?

A. Yes, sir.

560 Q. Did they get out of line again?

A. They did settle again.

561 Q. What was the character of the soil on which the engines were placed?

322 A. It was more of a quicksand than anything else. It seemed to be built over a former stream that had been filled in, which made a quicksand, and the more they dug down the worse they were off.

562 Q. In consequence of the settling was it so great that any part of the machinery became broken or deranged?

A. I think it did. I think it broke once or twice.

By Mr. Stoughton:

263 x Q. Was that before or after you repaired the foundation?

A. I think both times.

ROUSE P. WAIT sworn.

Examined by Mr. Thurston:

564 Q. Were you at any time engineer of the Providence Steam Rolling-Mill?

A. Yes, sir; for nearly two years.

565 Q. When you first occupied that position what was the means of regulation adopted in that mill?

A. Regulating by hand.

566 Q. What year was that?

A. I think 7 years ago this summer. I will not swear to it positively—7 or 8 years, I should think.

567 Q. What kind of rolling-mill was it?

A. To roll nail-plate and wire.

568 Q. Wire also?

A. Yes, part of the time.

569 Q. Was it not subject to great variations of load?

A. Very great; part of the time we would have a great load on, and part not any.

570 Q. What was the size of the engine?

A. 32-inch cylinder, 7 feet stroke, 30 turns.

571 Q. A beam-engine, was it?

A. Yes, sir.

572 Q. What method of regulation did you introduce after you first went there?

323 A. I put on a balance valve and pump regulator.

573 Q. What kind of pump regulator?

A. Pitchers, I think.

574 Q. Where was the balance valve located?

A. In the top of the side pipe.

575 Q. Was it a throttle valve or a cut-off valve?

A. It was a throttle valve.

576 Q. Was the regulator attached to the throttle valve?

A. Yes, sir.

577 Q. What was the effect upon the regulator after that combination was made?

A. A great deal better speed than we had before—steadier than I could regulate by hand.

578 Q. Was there any difficulty on account of the speed in the practical working of the machine?

A. There was not after I put the regulator in.

579 Q. Did you ever observe, and can you state as a matter of fact, what was the variation between the maximum and minimum speed of the engine?

A. I should say not over two revolutions a minute.

580 Q. You put that at the excess?

A. Yes, sir.

581 Q. How long did that method of regulation continue to be employed?

A. I think it is now.

582 Q. It was when you left, and is there now, for all you know to the contrary?

A. Yes, sir.

583 Q. Did you have any necessity to assist the engine in regulation by throttling?

A. Not at all. I gave the whole head of steam in the morning, and then the regulator took care of it till night.

Cross-examined by Mr. Stoughton.

584 x Q. When was the pitcher regulator put on?

A. I think about 6 or 7 years ago.

585 x Q. Was this valve which you call the throttle valve placed near the cut-off or at some distance from it?

A. I should say three feet from the upper valve.

586 x Q. Did you use any cut-off valve?

324 A. Yes; Sickles' cut-off.

587 x Q. The regulator you speak of was a water regulator?

A. Yes.

588 x Q. Before you got that peculiar kind of regulator, did you try the fly-ball governor for the valve?

A. Yes, it had been tried.

589 x Q. What was the result of that?

A. I do not know; I was not there. The fly-ball governor was up stairs when I went there, or part of it.

590 x Q. You never tried to use that, but regulated it by hand as well as you could?

A. Yes.

591 x Q. At what point of the stroke did you cut off with that engine?

A. Nearly one-half; I varied it; when light, at $\frac{1}{4}$; when heavy, at $\frac{1}{2}$.

WILLIAM W. BATTEY sworn.

Examined by Mr. Thurston:

592 Q. What is your business?

A. I act as foreman to Thurston & Gardner, in the machine shop.

593 Q. How long have you been in that employment, occupying that position?

A. I think about 15 years.

594 Q. Are you familiar with the mechanical contrivance called Sickles' cut-off?

A. Yes, sir; I built a great many of them.

595 Q. State what instances you know of the combination of the regulator with Sickles' cut-off, how they are operated, and how the combination was effected.

A. We applied the regulator directly to the cam-rod in a great many instances.

(Mr. Curtis objected to evidence of the working of Sickles' cut-off, in combination with the governor, subsequent to Corliss' invention, as irrelevant. Objection sustained.)

325 596 Q. Are you familiar with the machine known as the Sickles dash-pot?

A. I am, sir.

597 Q. Do you know any instances in which that dash-pot, without any change in its structure whatever, operated to resist the fall of the valve by means of air, instead of by means of water?

A. I do, sir; several instances.

598 Q. State them.

A. I think one was in the Fall River American Print Works think it was running for several years.

599 Q. An instance where the Sickles dash-pot, designed for the use of water, has been employed to resist the fall of the valve by air inside, instead of water?

A. The engine we run in Gardiner & Thurston's shop had two dash-pots fitted exactly alike; the one I ran on air, and the other on water; and it ran so for a long time.

600 Q. Were the two dash-pots alike?

A. Both alike—precisely fitted alike.

601 Q. One fitted to one valve and the other to the other?

A. Yes, sir; both made from the same casting and fitted equally. We ran it with air probably five or six months, until it got a little loose, and then we had to put in water.

602 Q. During the time no water was put in, the fall of the valve was resisted by an air-cushion?

A. Yes, sir.

603 Q. You say that mode of operation was continued until what occurred?

A. Until it leaked a little; it would not cushion enough.

604 Q. When did you say this was?

A. I think four or five years ago.

605 Q. How did the two valves operate, with respect to the manner in which they closed; was there any difference between the two?

A. I could see no difference; while the dash-pot was tight, one worked as well as the other. I mean to say that the valve working on air worked as well as the one on water, or the one on water
326 as well as the one on air. I could not perceive any difference between them while the dash-pot was tight.

Cross-examined by Mr. Stoughton.

606 x Q. Where do you now work?

A. At Thurston and Gardiner & Co.'s.

607 x Q. It was Thurston, Green & Co.?

A. Yes, sir.

608 x Q. And they made engines under Sickles' cut-off, under license from him?

A. I presume they did, sir.

609 x Q. When was the first instance, of which you have spoken, of working dash-pots with air instead of water?

A. The first one I spoke of was at Fall River; we had quite a number of them working.

610 x Q. That was seven or eight years ago?

A. Yes, sir.

611 x Q. Did you testify in the case of Sickles *against* Youngs and Cutler?

A. I think not, sir.

612 x Q. Did you testify in the case of the Gloucester Co.?

A. Where was the trial?

613 x Q. Did you not testify before a commissioner, in Providence, in a case pending between Sickles and the Gloucester Company?

A. I testified in Providence.

614 x Q. Do you remember who it was you testified before?

A. I do not; when I testified it was in court, I think.

615 x Q. Did you testify in reference to this dash-pot?

A. I cannot recollect now what it was.

616 x Q. Did you have drawings made in accordance with the patent of Sickles when you made this dash-pot and appartus?

A. Yes, sir.

617 x Q. And you worked in accordance with those drawings?

A. Yes.

327 618 x Q. Made your dash-pots in accordance with it in all instances?

A. Yes, sir; I took it to be in accordance with Mr. Sickles' invention.

619 Q. Did you vary the drawings at all, except in the way of size, for making the dash-pot?

A. We kept the same form.

920 x Q. The same form that was indicated in the patent you maintained in making them?

A. I think we did.

621 x Q. Was the end of the plunger, as made by this concern, square or round?

A. The bottom was rounded off.

622 x Q. Always?

A. Slightly rounded.

623 x Q. What was that for?

A. I do not know we had any particular reasons, except that bringing square down to the shoulder leaves a corner.

624 x Q. Was it not to go into the water easily?

A. The bottom end of it striking into the bottom reservoir requires the corner to be taken off so as not to strike square into the water.

625 x Q. That is the way you made them?

A. Yes, sir.

626 x Q. Did you ever understand water to be incompressible?

A. I do not know that I did.

627 x Q. Suppose you made the plunger to enter the pot air-tight and square at the end, it would have gone in with a pretty severe blow, would it not?

A. Yes, sir; I suppose it would.

628 x Q. It would not have struck air with so severe a blow, would it?

A. No, sir; not so hard.

629 x Q. You would not need to round off the corner with air?

A. No, sir; not so much.

630 x Q. Were not the dash-pots you made all made for the purpose of working with water in the pot?

A. I do not know.

631 x Q. Which one was intended to work with air?

328 A. The one in Fall River cushioned on air.

632 x Q. How long was this after the first controversy between Corliss and Sickles?

A. I cannot say.

633 x Q. It was after that?

A. I think it was.

634 x Q. It was after you thought it material to show there was not any difference between the use of air and water, was it not?

A. I do not know.

635 x Q. You know there was a controversy between Sickles and Corliss, whether air and water was the same, when used for that purpose?

A. Yes, sir.

636 x Q. Was it not for the purpose of trying to show there was not any difference?

A. No, sir.

637 x Q. Do you prefer air to water?

A. In some instances.

638 x Q. Which do you think is best, air or water?

A. I do not think there is any material difference; I think it requires a tighter pot to work on air than it does on water.

639 x Q. The rod that carried your plunger, in cases to which you have referred, worked through two stuffing boxes, what would be the effect of screwing up these stuffing boxes; would it not be to arrest the descent of the valve?

A. Yes, sir.

NELSON MATTISON sworn.

Examined by Mr. Thurston:

640 Q. What is your employment?

A. Steam engineer.

641 Q. By whom are you employed?

A. Dexter & Bro., North Providence.

642 Q. How long have you been in their employment?

A. A little over four years.

643 Q. What description of motive power do the Messrs. Dexter use in their mills?

329 A. Mr. Green's engine.

644 Q. Point out which of these models you recognize as being what they use?

A. Model No. 1 [defendant's.]

645 Q. To what is the regulator attached?

A. To the gauge bar.

646 Q. After any one tapit is engaged with the corresponding rocking lever, for the purpose of opening the valve, is there any power in the governor during that engagement to alter the position of this tapit, up or down?

A. There is not, sir.

647 Q. How do you know that to be the fact?

A. I watched it. When the tapit comes in contact with the rocking lever, it pins the gauge bar so that the regulator has no influence over it.

648 Q. Have you made any experiment or tested it in any manner?

A. There have been experiments tested on it.

649 Q. State what they were.

A. You mean in regard to friction? Mr. Renwick and Mr. Copeland came there and disconnected the spindle from the gauge bar, and applied 71 lbs. on the top of the gauge bar to depress the tapits from the rocking lever. It took 71 lbs. I think the engine was nearly on the centre.

650 Q. The result of that experiment was to take 71 lbs. to depress the tapits from the lever?

A. Yes, sir.

651 Q. Now, in the working machine, is the governor capable of exerting any such force as that?

A. No, sir; the governor balls are balanced nearly.

652 Q. How large a governor is it on the machine?

A. I think the balls on the governor weigh 15½ lbs. each. I think they are about six inches in diameter.

653 Q. What is the size of the rod connecting the gauge bar with the sleeve of the governor?

A. About a quarter of an inch.

654 Q. Since the experiments of Messrs. Renwick and Copeland, were any subsequent experiments made to verify that?

A. There have been by Mr. Renwick and Mr. Harris.

330 655 Q. Was it the same Mr. Renwick that made the other experiment?

A. No; his brother, Edward Renwick.

656 Q. In the course of the experiment made by Mr. Edward S. Renwick, was there any difference in the result?

A. Yes, sir. He placed the engine in a different position to what Mr. H. Renwick and Mr. Copeland did on the first test. They put her on to nearly a quarter of the stroke, and blocked the wheel.

657 Q. You say that in the first experiment the engine was on her dead centre?

A. Very nearly.

658 Q. And in the experiment tried by Edward S. Renwick?

A. It was half way from the dead centre to the quarter centre. Then we blocked the wheel.

659 Q. How much did it then take to move the tappets from the rocking arm?

A. 52 lbs., I think.

660 Q. In the position in which they tried it last was there an advantage of leverage?

A. Yes, sir.

661 Q. In that position of the parts they would be separated more easily than in the other position?

A. Yes, sir.

662 Q. And in this position it took 52 lbs.
A. Yes, sir.

By Mr. Curtis:

663 x Q. Did Thurston, Green & Co. build this engine?
A. They did.
664 x Q. When originally put in, what arrangement for cut-off had it?
A. The same it has now.
665 x Q. What engine had you before?
A. I was not there, and do not know. I never ran the old machine if they had one.
666 x Q. How many revolutions a minute does this make?
331 A. Fifty.
667 x Q. How many times in each revolution is the tappet released?
A. Once.
668 x Q. Each tappet, then, is released fifty times in a minute, free to act?
A. Yes.
669 x Q. The engine regulates well does it not?
A. Yes, sir.

GEORGE P. TEW sworn.

Examined by Mr. Thurston:

670 Q. What is your business?
A. Jeweller.
671 Q. Are you a member of any firm in Providence carrying on that business; and if so, what firm?
A. Yes; the firm of Sacket, Davis & Co.
672 Q. Manufacturing jewelry?
A. Yes.
673 Q. In your establishment have you motive power?
A. Yes, sir.
674 Q. State to the court how your establishment is situated with regard to the use of power—whether you use the whole yourself or let it out to other parties.
A. We let power to eighteen different parties, besides using it ourselves.
675. How many different buildings do you communicate your power with?
A. Six.
676 Q. And the communication is made by shafting?
A. Yes, sir; some part.
677 Q. The persons who hire this power—for what particular trade or manufacture is it?
A. All in the same business—jewelry.
678 Q. State whether or not the load upon your engine is a regular or irregular one?
A. It is an irregular load.

679 Q. Why irregular?

A. We use a great many rolls for rolling gold and silver—
332 some very heavy ones. All those shops use two sets; some more. We have two heavy sets and some smaller ones. Sometimes all are on; sometimes few or none, which makes the amount of power used very irregular.

680 Q. Six months ago whose engine did you use?

A. Mr. Corliss' engine.

681 Q. What kind of engine was it?

A. I do not know what kind. It was a beam engine. I suppose a high-pressure engine.

682 Q. It was one of his improved engines?

A. We supposed it to be.

683 Q. What sort of regulation did you obtain from that engine in the effect upon your machinery?

A. We have never had any machinery that required any very accurate running until within two or three years. I think it was three years since we started some very fine chain machines, and we found they were so unsteady that we could not run them. We were obliged to put on what some call a friction wheel to run that part of the shop steadier. We did that, and we could see every time the engine took steam it would pass on the racket. Our machinery ran steadier after that.

684 Q. The friction wheel was introduced to counteract the difference?

A. Yes, sir.

685 Q. At that time you had a Corliss engine?

A. Yes, sir.

686 Q. Is the model on the judge's table, to your eye, a representation of the engine you had there?

A. I do not see the beam. The other parts look like the one we had.

687 Q. Was the regulator in that machine connected with the cut-off?

A. I cannot tell.

688 Q. Did it have a regulator upon it?

A. Yes, sir; it had.

689 Q. Was it any different from the other engines of Mr. Corliss you have seen in respect to the mode of regulation?

A. No, sir. I understood it to be one of his regular improved steam-engines.

333 690 Q. Were you a member of the firm at the time it was put in?

A. I was not.

691 Q. Were you employed at the establishment?

A. Not until a short time after.

692 Q. I understand you to say it was not different, so far as you know, from other machines of Mr. Corliss. Can you state to what the regulator was attached in the machines of Mr. Corliss?

A. No, sir; I cannot.

693 Q. You are not sufficiently familiar with the construction of the thing?

A. No, sir.

694 Q. Can you state whether it did cut off.

A. It did cut off.

695 Q. Worked expansively?

A. Yes, sir.

696 Q. Can you say whether the cut-off was adjusted by the engine by hand or by any contrivance in the engine?

A. It was regulated by a contrivance in the engine.

697 Q. Other persons have seen the engine. Has Mr. Beatty seen the engine?

A. I cannot say.

898 Q. Was that engine ever removed at any time?

A. Yes, sir.

699 Q. How long since?

A. It was removed in June last.

700 Q. What was substituted for it, if any?

A. One of Mr. Green's engines.

701 Q. Is the principle of that engine similar or dissimilar to any model on the judge's bench?

A. Similar to that brass model, [defendant's.]

702 Q. What advantage, if any, in the result upon the machinery in respect to regulation did the introduction of Mr. Green's engine accomplish?

A. We have never tried our chain machinery with the friction wheel off; but when it takes steam we cannot notice it on the friction wheel, which we could before.

703 Q. Do you mean to say that at every revolution of the engine you heard the click with the Corliss engine?

A. Yes, sir.

334 704 Q. How often did you observe the click on the friction wheel after Mr. Green's engine was introduced?

A. I cannot say.

705 Q. Did you observe the click at the ordinary working hours or at certain periods of the day?

A. Occasionally you would leave it through the day. There was no regularity about it. We supposed it to be when we threw off heavy rolls.

706 Q. With respect to the economy of the engines, what was the difference between the Green and Corliss engines in the consumption of fuel?

A. We are making a saving of from 30 to 31 per cent.

707 Q. Over Mr. Corliss'?

A. Yes, sir.

708 Q. Was the engine substituted for Corliss' put in at a fixed price, or on what terms?

A. The price was to be taken out in the saving of fuel; we were to pay them that, or a certain sum of money.

709 Q. Before the engine of Mr. Corliss was taken out and Mr.

Green's substituted, was the old engine at any time put in order by Mr. Corliss?

A. Within a year of that time it was thoroughly repaired, the cylinder rebored, the valve seat rebuilt, and, I think, some new valves. I am not positive about that.

710 Q. From the amount of work on it, what was the expense per year?

A. I know the expense for the last three years—$750, about.

711 Q. After it was put in order by Mr. Corliss, can you state whether or not it was reported by him to be in good order?

A. I never talked with Mr. Corliss; I talked with Mr. Clarke, their agent, as I understood it, and he said he supposed it was fixed as well as it could be fixed.

Cross-examined by Mr. Stoughton.

712 x Q. How long had you been using the engine before you changed?

A. I should think it was nine years this summer—eight or nine years.

335 713 x Q. When you put this engine in, about nine or ten years ago, with what building did you communicate shafting?

A. I think just the same number as now.

714 x Q. How many persons do you supply with power?

A. I think there is no change in the number of persons.

715 x Q. Have you used more or less power since you made the change?

A. We are using more now.

716 x Q. How as to the persons to whom you rent?

A. They are all driving now. Most of the time since this engine has been in we have been very busy.

717 x Q. How many revolutions did you run the old engine?

A. I am not positive—I think thirty-five.

718 x Q. How many do you run this of Green's?

A. I think forty-five to fifty.

719 x Q. The same sized engine?

A. The cylyinder is the same size—six inches less stroke—fourteen inches cylinder.

720 x Q. And you run it at forty-five to fifty revolutions?

A. Yes, sir.

721 x Q. How much coal do you use?

A. About 1,300 lbs. a day.

722 x Q. You think you have not tried to run the Green engine without the use of the friction wheel, but you think it runs a little more regularly than the other?

A. I know it does.

723 x Q. Do you attribute that to the fact that you cannot change the relation of the tappets on the Green engine?

A. I do not know, sir. I only know the fact. I only know that when the other engine took steam we could feel it every time.

724 x Q. Would it not make it run more regular if you ran faster?

693 Q. You are not sufficiently familiar with the construction of the thing?

A. No, sir.

694 Q. Can you state whether it did cut off.

A. It did cut off.

695 Q. Worked expansively?

A. Yes, sir.

696 Q. Can you say whether the cut-off was adjusted by the engine by hand or by any contrivance in the engine?

A. It was regulated by a contrivance in the engine.

697 Q. Other persons have seen the engine. Has Mr. Beatty seen the engine?

A. I cannot say.

898 Q. Was that engine ever removed at any time?

A. Yes, sir.

699 Q. How long since?

A. It was removed in June last.

700 Q. What was substituted for it, if any?

A. One of Mr. Green's engines.

701 Q. Is the principle of that engine similar or dissimilar to any model on the judge's bench?

A. Similar to that brass model, [defendant's.]

702 Q. What advantage, if any, in the result upon the machinery in respect to regulation did the introduction of Mr. Green's engine accomplish?

A. We have never tried our chain machinery with the friction wheel off; but when it takes steam we cannot notice it on the friction wheel, which we could before.

703 Q. Do you mean to say that at every revolution of the engine you heard the click with the Corliss engine?

A. Yes, sir.

334 704 Q. How often did you observe the click on the friction wheel after Mr. Green's engine was introduced?

A. I cannot say.

705 Q. Did you observe the click at the ordinary working hours or at certain periods of the day?

A. Occasionally you would leave it through the day. There was no regularity about it. We supposed it to be when we threw off heavy rolls.

706 Q. With respect to the economy of the engines, what was the difference between the Green and Corliss engines in the consumption of fuel?

A. We are making a saving of from 30 to 31 per cent.

707 Q. Over Mr. Corliss'?

A. Yes, sir.

708 Q. Was the engine substituted for Corliss' put in at a fixed price, or on what terms?

A. The price was to be taken out in the saving of fuel; we were to pay them that, or a certain sum of money.

709 Q. Before the engine of Mr. Corliss was taken out and Mr.

Green's substituted, was the old engine at any time put in order by Mr. Corliss?

A. Within a year of that time it was thoroughly repaired, the cylinder rebored, the valve seat rebuilt, and, I think, some new valves. I am not positive about that.

710 Q. From the amount of work on it, what was the expense per year?

A. I know the expense for the last three years—$750, about.

711 Q. After it was put in order by Mr. Corliss, can you state whether or not it was reported by him to be in good order?

A. I never talked with Mr. Corliss; I talked with Mr. Clarke, their agent, as I understood it, and he said he supposed it was fixed as well as it could be fixed.

Cross-examined by Mr. Stoughton.

712 x Q. How long had you been using the engine before you changed?

A. I should think it was nine years this summer—eight or nine years.

335 713 x Q. When you put this engine in, about nine or ten years ago, with what building did you communicate shafting?

A. I think just the same number as now.

714 x Q. How many persons do you supply with power?

A. I think there is no change in the number of persons.

715 x Q. Have you used more or less power since you made the change?

A. We are using more now.

716 x Q. How as to the persons to whom you rent?

A. They are all driving now. Most of the time since this engine has been in we have been very busy.

717 x Q. How many revolutions did you run the old engine?

A. I am not positive—I think thirty-five.

718 x Q. How many do you run this of Green's?

A. I think forty-five to fifty.

719 x Q. The same sized engine?

A. The cylyinder is the same size—six inches less stroke—fourteen inches cylinder.

720 x Q. And you run it at forty-five to fifty revolutions?

A. Yes, sir.

721 x Q. How much coal do you use?

A. About 1,300 lbs. a day.

722 x Q. You think you have not tried to run the Green engine without the use of the friction wheel, but you think it runs a little more regularly than the other?

A. I know it does.

723 x Q. Do you attribute that to the fact that you cannot change the relation of the tappets on the Green engine?

A. I do not know, sir. I only know the fact. I only know that when the other engine took steam we could feel it every time.

724 x Q. Would it not make it run more regular if you ran faster?

A. I do not know. Our shafting runs the same. There is no variation in the shafting.

725 x Q. You have got the same fly-wheel on?

A. No, sir: a different fly-wheel.

726 x Q. A larger or smaller one?

A. I think a little smaller.

336 727 x Q. Have you any recollection of Mr. Clark advising you to put the speed up, to enable you to pass the centres with more regularity?

A. Not to me.

728 x Q. Would not that enable you to work with more regularity, to put on more speed?

A. I have no idea about it.

ERASMUS D. LEAVITT, jr., sworn.

Examined by Mr. Thurston:

729 Q. Were you formerly in the employment of Mr. Corliss?

A. I was, sir.

730 Q. Your business is—what?

A. I am an engineer, in the employment of Thurston, Green & Co.

731 Q. Were you acquainted with the engine in Sackett, Davis & Co.'s?

A. Yes, sir.

732 Q. I mean the one that preceded the Green machine now in it?

A. Yes, sir.

733 Q. What kind of engine was it?

A. A beam-engine, fourteen-inch cylinder, four feet stroke. It had a cut-off like on that model. It had the same general construction.

734 Q. Had it a regulator?

A. Yes.

735 Q. And supposing the governor balls revolved in different planes, what was the effect on the rod?

A. To raise or depress the wedge-rod.

736 Q. What effect would it have on the valve?

A. To force the steam in and out, and trip the valve sooner or later.

HENRY B. RENWICK sworn.

Examined by Mr. Dickerson:

737 Q. Have you examined the reissued patent No. 763, in this case, to Geo. H. Corliss?

337 A. I have, sir, frequently—a copy of it.

738 Q. And the model and drawings that were produced as illustrations of it?

A. I do not know that I have ever seen the drawings making part

of this reissue No. 763. I am very familiar with the drawings of the original patent and of the first reissue.

739. Q. What is your occupation and position at present?

A. I am a consulting engineer. I am United States steamboat inspector for the southern district of New York; and I do some business with the Patent Office in getting out patents.

740 Q Are you familiarly acquainted with steam-engines and their operation, and the history of the different kinds?

A. I believe I am, sir. I have read of, and seen, all I could manage to see about it since I was 12 years old.

741 Q. Have you been practically connected with the construction and operation of steam-engines?

A. I have been practically connected with their operation; have been consulted as to and devised plans for their construction.

742 Q. Look at copy of the reissue No. 763; also at drawings figs. 8 and 9, and say whether you find on the drawings of the reissued patent the drawings represented in figs. 8 and 9 of the original?

A. They are not there, sir. The figs. 8 and 9, so far as I remember, were a part of the original patent and of the first reissue. They are not found in the reissue No. 763.

[Mr. Stoughton stated that they were annexed to the patent for the wrist motion.]

743 Q. State what is described and specified in patent No. 763.

A. What is described here as the invention of Mr. Corliss is the combination of a regulator with a liberating valve gear for regulating the velocity of steam-engines. The specification describes specifically the precise way of accomplishing that result by means of that combination, and also sets forth, as I understand it, that any form of regulator may be used, or any form of liberating valve gear. The patentee defines, in his specification, what he means by a reg-
338 ulator and what he means by a liberating valve gear. He says, on line 17, that the regulator "is an instrument which, when set in motion, changes the relative position of some of its parts as changes occur in its velocity, and by virtue of such changes is capable of communicating motion to other mechanism." That is the definition of every regulator or governor with which I am acquainted. They all have that characteristic.

744 Q. Are there many forms of governor?

A. Yes, sir; any quantity of them. There is the common fly-ball governor, which acts to govern by raising or depressing a sleeve or stop which works directly from and with the varying height of the balls. There is what is known as the bellows governor, where two bellows blow air into a third vessel, shaped like a bellows, loaded on the top with weights or a spring, and having a hole in it to let the air out; so that when the machine which drives the bellows goes too fast, the air cannot all escape through the hole, and the top of the bellows rises, and, in the words of the patent, "changes the relative position of some of its parts;" and when the machine goes too slow, the top of the third vessel falls, and communicates motion to something which regulates the machinery. There is also a thing known as the pump-

ing governor, which acts in one form of it, like the bellows governor, except that two pumps are substituted for the two bellows, and that the third vessel is a cylinder with a weighted piston, which piston rises when the pumps supply too much water, and falls when they supply too little. There are other kinds of governor, in which the rising and falling of the fly-balls sets machinery in motion in different directions—all of which may be comprehended under the common class of mill-governor, such as is shown in that French machine. There are still two other classes of governor—one of which is where the motion of the fly-balls does not act directly on the machinery to be governed, but acts upon the starting bar of a small water-engine, the motion of which water-engine communicates itself to the engine to be governed. And still another, where the governor sets in motion in different directions a small steam-engine, or rather enables the engine, which always moves in the same direction, to move some-
339 thing else in an opposite direction; so that the governor, instead of having to work, only tells this little engine to do it, and when and how far to do it.

745 Q. Under these different generic divisions, are there a great variety of modifications in detail?

A. There are, sir, combinations of the mill-governor and the common fly-ball governor, sometimes where the motions are taken from the common fly-ball governor, and sometimes where two fly-ball governors are used. There are a variety of different forms of the mill-governor and pumping governor.

746 Q. The atmospheric governor—do you know that?

A. There is another kind still—a governor which has been used in connection with clocks—seamen's chronometric governor. There is still another, which acts by the resistance of the air, where large vanes fly round, opposed to the resistance of the air, not much in use except in the striking mechanism of clocks.

747 Q. At and before the date of this patent were all the different contrivances of governor well known?

A. I knew of all, except the kind of mill-governor in which the fly-balls were connected with the little engine, and that kind in which the fly-ball governor set a small engine to do its work.

748 Q. In the books on engineering, do you find a great variety of drawings of these?

A. Yes; in *Buchanan on Mill Work*, a great variety of governors are described; and in another work, entitled *The Practical Mechanics' Assistant*, one addition of which I know of. There are two or three large plates devoted to different varieties of governor.

749 Q. Do you know any of these which are not practically operating governors, when constructed and applied to use in the proper manner?

A. I have seen them all in practical operation, except seamen's chronometric governor; that I never studied very carefully, and do not know much about.

750 Q. Is there any form of governor which you know of that is not included within the description of Corliss' patent?

A. As I said before, I know of no form of governor which is

340 not included within the definition of governor given in this patent. The patentee then defines what is the second part of the combination, which is the liberating valve gear, and he states (line 20) that liberating valve gear "is a valve gear which embodies two forces for operating the steam valves; the one for their opening movement, which may be derived from the engine itself; the other for the closing movement, which may be derived from weights or springs, or their equivalents." He then states that the "arrangement may be such," &c., widening out the general definition; but the general definition is given in the words I have just quoted. That kind of liberating valve gear embraced under the definition is known to me chiefly under two great forms—one of which is the cam or tappet valve gear—(the cam when it rotates, and the tappet when it runs in right lines)—in which the parts disconnect themselves by virtue of their own motions, being in different lines of direction; and the other great class of valve gear is that represented in models C and No. 3, [Sickles' patents of 1842 and 1845,] which differs from the cam valve gear, in the fact that a third instrument is called into play to effect the separation of the parts of the valve gear, so that the valve may drop by gravity, or by a weight applied to it, or by the force of a spring; and which, in addition, possesses the further peculiarity that if the valve sticks up from any cause, or if the liberation is not effected, then the engine of its own self, will return the valve and force it to its seat. That is a peculiarity not found in the cam liberating valve gear. In the cam valve gear, the valve is always lifted by the force of the engine, and always descends by the force of gravity or a spring. If the part of the cam on which the valve gear descends is made of a very slight inclination, then the valve may be controlled in its descending movement by the engine; but still its descent will be effected by means of gravity, and not by the engine. But if the form of the cam be such that the line on which the valve gear descends is radial, or nearly radial, or if the valve gear moves in such a relative position to the motion of the cam, as is shown in a great many instances, it is impossible for the cam to control the valve in its descent, and it descends by the force of gravity alone,
341 unchecked by the engine. I may state that I never saw a drawing of valve gear with such a gentle inclination of the face of the cam as would force the valve to slide down. [Refers to French model.] In this liberating valve gear the cam, as it comes round, lifts the valve. That comes within the definition that the force of the engine lifts the valve; as the cam goes farther round, the valve is returned to its seat by gravity, and so the gravity is the active force. Even in this valve gear, if the revolution be quick; even with this very gradual and gentle slope of the face, the cam cannot control the valve at all; for this reason, that gravity (if I may use the term) seems to think before it goes to work. After you have taken your finger from under the valve, [illustrating,] there is inertia to be overcome, and some little moment of time elapses before the valve begins to descend. The velocity of descent increases according to the square of the distance through which it descends, so that it

has a slow motion at first, and gives the face of the cam plenty of time to escape from under the roller before the valve descends; so that if the cam is moving up to the speed at which the engine usually moves, it would not control the descent, even with the gentle face shown here. Now, on this cam, if you move it very slowly, then, although gravity closes the valve, the valve will ride down on this gentle descending face; but if you move the engine at the speed of 50 or 60 revolutions, then the cam does not control it at all. The fact that it does not control it is shown by the blow of the roller on the surface of the cam; so that it is a two-fold question of inclination of surface and speed of revolution of cam. These are the two great classes of liberating valve gear that I know of, and they are both contained in the definition the patentee gives of his invention. Another reason I have for the opinion that the invention is the combination of any form of governor, with any liberating valve gear, is that it is distinctly stated in the specification (line 135:) "I wish it to be distinctly understood that the invention which I claim under this patent does not consist in the form of the regulator employed, nor in the form of the valves, nor in the form of the valve gear." Another
342 reason is this: There are stated in this patent as being old and well known several different kinds of engines, and those engines are stated to embody a common method of operation. This is on line 111: "But all these plans, under various arrangements of mechanism, embody a common method of operation, the same substantially as that in the engine referred to in Tredgold's Treatise." Now, the engine referred to in Tredgold's Treatise is a cam liberating valve gear with the ordinary fly-ball governor. One of the other engines referred to as being substantially the same in method of operation is also a cam valve gear, but with a mill-governor. Now, if these two engines be substantially alike in the mode of operation, the mill-governor in the combination must be an equivalent for the fly-ball governor. In reference to this statement I would observe that in one of the engines referred to in the patent as old, the position of the cam is not varied; the cam always stands still; but the governor shoves a very little roller along the face of the cam, and I agree with what the patentee asserts, that that is the same mode of operation, except so far as mechanical device is concerned, and substantially the same thing, whether you move the cam or move the roller. As the invention is stated to consist in a combination of liberating valve gear with a governor, it appears to me that it is a matter of no consequence, so far as the party's invention is concerned, whether the valve to which the valve gear is applied be the main steam valve or be the cut-off valve outside of the main steam valve. He himself states in effect that it is substantially the same thing to apply the valve gear to the main steam valve, or to the cut-off valve, acting outside of that. The reason is, that he says these various engines to which he has referred "embody a common method of operation, the same substantially as that in the engine referred to in Tredgold's Treatise." In these engines, in some of them, the liberating valve

gear is applied to the valve, outside of the main steam valve, and in the others directly to the main steam valve.

751 Q. On the 27th line of his description the patentee says: "The liberating valve gear presents, as I have discovered, peculiar features of adaptation for working in combination with a regulator, as it has
the capability, beyond other species of valve gear, of reducing
343 the amount of power required of the regulator in controlling
the periods of closing the valves, and also of reducing the range of movement required of the regulator in fulfilling the requirements of regulation." What do you understand that part of the description to refer to and describe?

A. In both the cam valve gear and the valve employed by Sickles the valve gear is out of connection with the valve entirely, while the valve is on its seat. Therefore, the governor is not hampered by any weight or motion of the valves at this period of time, and the governor is specially applicable to that kind of valve gear. But in other kinds of valve gear to which the governor has been applied—take, for instance, those in the *Practical Mechanics' Magazine*, where there are two slides always under the control of the engine, both to open and shut the valve—the governor in that class of engines which have not liberating valve gear of either variety has always to act and will be hampered while the engine has to do the whole work of moving one valve.

752 Q. In that kind of valve gear represented by that rotating cam, suppose the engine to be running 50 turns a minute, how many times a minute is the governor released from any pressure of the valve, and at liberty to change the stop or cut-off?

A. If running 50 revolutions a minute, it is liberated 50 times; that is to say, when the valve falls in its seat during 50 times in each minute, the governor is free to act. During other fifty times in the same minute the governor is hampered by the friction on the cam. But in the slide valve the governor has always to act, hampered by the power of the engine necessary to move the valve. I do not mean that the whole power is there.

753 Q. Inform the court under which of the forms of liberating valve gear you have described the machine exhibited by the drawings and model connected with the patent comes.

A. The machine exhibited and specifically described as embodying the invention comes under the form of liberating valve gear, in which
a third instrument is necessary to come in and effect a separa-
344 tion of the parts. The machine specifically described in the
patent and drawings is of that form of liberating valve gear.

754 Q. Explain on what form of liberating valve gear, and at what time, and in what manner, the governor performs its functions in the combination.

A. In that form of liberating valve gear which may be illustrated by the blackboard, or by either of these models, the governor operates to direct the position of the third instrument, which effects the disconnection or separation of the parts, and the free working of the governor is only impeded just at the instant of separation of the parts,

whereas in the other form of liberating valve gear [the cam form] the governor is impeded in its operation during the whole time that the valve is off its seat not only when lifting, but while it stays up. The governor is being impeded by the weight of the valve, and it continues being impeded until the valve is liberated, and then the governor is free, so that the governor is hindered in this species of valve gear more than in the other.

Now, that question of the impeding of the governor, for the time it is impeded, is, practically speaking, not of so great moment, because the governor is like the steam-engine; if you make a little steam-engine you can tie it fast by a thread, but if you make a big steam-engine the thread will have no effect upon it to hold it fast at all. So if you have a big governor it will go through all the resistances and not feel them so much as to be hindered in its operation.

755 Q. I call your attention to this peculiarity of the two forms; in *that* form of detachable valve gear the time during which the governor is impeded is a constant quantity at all times?

A. It is, sir.

756 Q. Whether the engine be cutting off long or short?

A. The proportion of time to the whole operation is always the same, no matter whether the engine is cutting off short or long; whereas in this form, with the cam, the proportion of time that the governor is hampered depends on the length of the cut-off at
345 that time. If the cut-off is very short the governor is only hindered a short time; if the cut-off is long the governor is hindered in proportion.

757 Q. Suppose the engine to be running at half-stroke at each end of the stroke?

A. Then the governor would be hindered just half the time with the cam-liberating valve gear.

758 Q. Suppose it were the whole stroke?

A. If it were working the whole stroke, or nearly so, the governor would be impeded the whole of the time.

759 Q. Then suppose the governor were called upon to shorten the period of cut-off on the cam-liberating valve gear?

A. The time at which the governor is hindered varies. The more it goes towards short cut-off the less time the governor is hindered.

760 Q. On detachable valve gear where the third instrument is employed?

A. It is always hindered the same time, no matter whether the engine be cutting off at almost nothing, or follows to the end of the stroke, the engine is hindered nearly the same amount of time.

761 Q. Look at the model of the Green engine, to which form of liberating valve gear does that machine belong?

A. This machine belongs to the class of liberating valve gear which is known as the cam-liberating valve gear. There is no third instrument required to make a separation of the parts to let the valve fall by gravity. It has all the distinctions peculiar to that form of valve gear.

762 Q. Explain to his honor how the engagement and disengagement on that machine is effected, and what effect they produce upon the operation of regulation? [Green machine.]

A. In this form of valve gear, the tappet, (which may be called the cam,) by the acting face of the cam comes in contact with the lever attached to the valve and opens the valve, and then the parts, by reason of one having a motion in one direction and the other in another direction, separate themselves from one another without the operation of a third instrument; and as refers to the method of regulation (which I suppose refers to the time the governor is hampered) it is exactly the same as in the cam valve gear. Now,
346 suppose the governor, in this machine, were to try and move the stop, it would be hampered during the whole time these two faces were in contact with each other. Therefore the time during which the governor is hampered in this engine is precisely the same as in the cam-engine.

763 Q. Suppose the engine to be running more than half stroke, what would be the proportion of time the governor would be hampered?

A. It would be more than half the whole time. The governor would be practically pinned fast, by the fact that these two parts were in contact.

764 Q. Explain how that reciprocating tappet and the revolving cam are alike in their operation, as you say they are of the same type?

A. Both operate precisely in the same way. [Illustrates.] Now, you see the projecting part up from that cam is in contact with the instrument that moves the valve, the projecting part of *this* tappet is in contact with the instrument that moves the valve. The valve begins to raise in both instances and keeps up until the parts get in such a position that, by reason of their moving in different directions, the valve drops; and in both cases the time during which the valve remains up is determined by the amount of surface the cam or tappet has travelled over the face of the lever that is attached to the valve. If there is a greater amount of surface on that instrument thus travelled over by the mechanism attached to the valve the valve remains up longer.

765 Q. In respect to the return or getting back of this cam, so as to be able to commence its next operation, explain wherein these two differ and are alike?

A. They differ as mechanical devices, but are alike in mode of operation. [Illustrates.] The one does it by revolution and the other by a reciprocating motion.

766 Q. In both cases what power puts it back to its place?

A. In both cases the power of the engine. The power of the engine puts the protuberant part of the cam back to its place by giving a revolution to the shaft. In this machine [of the defendant's] the power of the engine puts this stop back by throwing the
347 tappet against the bottom of the valve lever. While the engine is depressing the tappet it also winds up this spring, and when the tappet passes by, the power of that spring throws the tappet up into place again. So the power of the engine both do-

presses the tappet and returns it again to its place for operation, as in that cam gear.

767 Q. As a mechanical device they are different, but as a mode of operation the same?

A. They are the same.

[By the court.] 768 Q. On the machine of Mr. Corliss, what is the time at which the valve gear is detached, and through what instrument is it done?

A. The governor does it through a third instrument, which effects the detachment, called the helical cam.

769 Q. What fixes the time at which the parts are to detach in defendant's engine?

A. It is done through the instrumentality of this stop, regulating the height to which the engine shall drive up this cam. In the one case the engine sets the stop to the position indicated by the governor, and in the other case the governor sets the stop and also effects the disconnection.

[By Mr. Dickerson.] 770 Q. When this cam arrangement is used, to be connected with the governor to regulate the engine, explain to the court how and by what instrumentality. What is the instrument on this French model which determines the time that the valve shall close?

A. It is the same, in mode of operation as this engine [Greene's] precisely, in the French engine. The governor fixes the time at which the valve should be shut, and does it by fixing the position of the stop or yoke, and that stop or yoke determines the position of the cam, as in this case [Green's] the stop or yoke determines the position of the tappet.

771 Q. In this case explain how that determines the length of time the valve should be up.

A. Because, if the stop is moved to the right hand it shortens the cut-off; if moved to the left, it lengthens the period of cut off;
348 the motion of this stop is governed by the position of the governor.

772 Q. In this French engine suppose the governors were disconnected entirely—not in operation at all—how would that cut off?

A. It would go on cutting off at whatever positions the tappets happened to be set, if the governor and stop were both taken away. In *this* engine [Greene's] in the same way, if you take away both the governor and stops, the engine would go on cutting off at whatever position the tappets happened to be set.

773 Q. [By Mr. Stougton.] Do you say the stop and gauge bar do not perform the same office?

A. No, sir.

774. Q. [By Mr. Dickerson.] In the plaintiff's particularly described engine suppose you take away the thing he calls the gauge bar, does the engine cut off then?

A. No, sir; it will not cut off at all. In the machine specifically described in the plaintiff's patent, if you take out the thing he spe-

cifically describes as the stop or gauge bar, the engine will not cut off at all, but will follow full stroke.

775. Q. [By the court.] You say, in answer to the question put to you, that the stop or gauge bar does not perform the same office. Do not both fix the point when contact shall cease?

A. They fix the point when contact shall cease; but that is the office of the governor. The stop in the defendant's engine does not effect the liberation, nor does it in the French engine.

776 Q. I do not mean to effect liberation, but fixing the time.

A. Yes, sir; they fix the time.

777 Q. [By Mr. Dickerson.] Assume the word gauge bar to be common to all the machines, do you find that same thing in the French machine?

A. Assuming it to be the instrument attached to the gov-
349 ernor, fixing the point of cut off, I find it in the plaintiff's, in the defendant's, in the French, in Tredgold, and in five or six others.

778 Q. Assuming the gauge bar to be an instrument, whose office it is to determine the time when the cut off should take effect?

A. It is in all the engines referred to by the plaintiff to give it that broad and general definition, and a good many others.

779 Q. Looking at model X, will you exhibit on that model the mode of operation that is there illustrated, and tell the court what it is?

A. [Illustrating.] *This* represents the valve; that valve is acted upon by a vibrating lever, the same as in the French engine, and in the defendant's engine. Then on this sliding bar there are two different varieties of tappets; one of the tappets, with a brass piece on it, is made like the face of the French cam—like the acting part of the French cam; the other tappet is like the tappet in the defendant's engine. In the French engine the front part of the cam strikes the lever, lifting the valve. The valve stays up as long as the lever is in contact with the acting face of the cam; and when it gets beyond the acting face of the cam, it drops. This hinder tappet represented in the defendant's engine strikes the lever, lifts the valve, and as long as the face of the tappet remains in contact with the face of the lever, it holds the valve up, and then the valve drops. In the French engine if the stop were applied to this model, so as to hold the cam in the position I now hold it, so that a very small portion of its surface is in contact with the tail of this lever, the valve stays up a short period of time; but let it all the way out, so that a long part of the surface is in contact, and the valve will stick up a long period of time, and the period of cut off be lengthened. By the defendant's engine, if a long part of the surface is permitted to be in contact with the lever, the valve stays up a long time; but if this part of the surface comes in contact with the tail of the lever a short time, the valve will stay up but a short time.

780 Q. [By the court.] And that, whether greater or less, depends on the regulator?

350 A. Yes.

781 Q. [By Mr. Dickerson.] Taking the two cases together, do you say that the machinery described by Mr. Corliss is substantially the same, or substantially different, considered as a mode of regulation from that exhibited in the defendant's model and the French model? Confine yourself to the machinery he has described in his specification or in his drawing.

A. The machinery minutely described in the drawing, without going into the part I spoke of before, describes that kind of liberating valve gear where a third instrument is required to effect the disconnection. That kind of liberating valve gear does not exist either in the French engine or in the defendant's engine.

782 Q. Assuming this patent to be a patent for the combination of a liberating valve gear of any of the known forms of liberating valve gear, with any governor of the various forms of governor, be good enough to say whether this French engine is included within the patent of the plaintiff?

A. Supposing his invention to be the combination of a governor of any form with liberating valve gear, as he defines it, both this French engine and the Tredgold engine, and other French engines referred to in the patent, are all within the description of the patent, as well as the engine of the defendant's.

783 Q. On the other hand, assuming it to be a patent for controlling the engine by combining the governor with a liberating valve gear substantially such as that described in the drawing, and particularly specified in that description, then what would be your answer?

A. Assuming the invention to be the combination of a governor with that species of valve gear minutely described, and which I would call a tripping valve gear, then the French engine and Tredgold engine are not described in the patent, and the defendant's engine is not found in the patent.

784 Q. Taking that French engine, have you examined the description in the book referred to on page 9 of the answer?

351 A. The French engine is referred to in the plaintiff's patent. The first engine referred to in the answer and the patent is in vol. 5, *Armengand*, plate 38. [Book offered in evidence.] Fig. 38, here, is an engine substantially like the Tredgold engine, with one difference, which is a mechanical one, and does not effect its mode of operation. *Here* [illustrating] is a cam. Now the cam revolves in this direction, and the roller falls off on this sharp side of the cam so as to permit the valve to be dropped by gravity, and not be controlled by the engine. But it is different from Tredgold's in respect that the governor does not slide the cam along. But suppose this cam in Tredgold's was stationary, and that there was a long spindle attached to the end of this lever, with a little roller on it, and then that the governor moved this little roller over the face of the cam, that is the engine described on plate 38 of the 5th vol.

785 Q. The roller giving the motion?

A. The detachment is the same as in Tredgold and the French en-

gine; but instead of sliding the cam along, the governor operates upon the roller.

786 Q. Describe the difference between a cut-off outside of the distributing valve and a cut-off at the steam valves.

A. This Tredgold model of cut-off is on a valve outside of the main steam valve. It is generally called an expansion valve. It is not a throttle valve, nor in its action anything like a throttle valve. Its action would be like two doors leading into the same room. [Illustrates.]

787 Q. The phrase "expansion valve" is a technical term signifying those outside valves?

A. It is, sir.

788 Q. As a general fact in machinery, take all the English steamers, how do they work their expansion?

A. A great many work their expansion in the main valve by a lap of the lead in the main slide valve, or by two expansion valves.

789 Q. How do the Cunard line work?

A. As far as I know, they effect their expansion by the lap of the lead in the main slide valve.

352 790 Q. I now call attention to the other book, *Traitée des Machines a Vapeur*, published at Paris in 1847, page 270.

A. It differs a little in some points of arrangement, but in so far as it has a mill-governor and a yoke to regulate the position of the cams, and valve levers and cams acting on the tails of these levers, it is the same as this model.

791 Q. Refer to the 6th vol. of *Armengand*. What is stated in the text that describes this engine as its mode of operation in respect to this problem of regulating by means of the governor there used?

A. In *Jullien and Battaille* the author states that the change of load in the engine is very great; that it goes often from no load at all on the engine to the maximum load, and that the application of a variable cut-off to this engine was indispensable. He then says in another place that, in his opinion, another form of mill-governor would perhaps be better than this governor, as it would not regulate quite so fast as this governor would.

792 Q. What do you understand by that description to regulate not quite so fast?

A. I mean that, for instance, a load is thrown off the engine at one time it will not reduce the quantity of steam quite so fast as *this* form of mill-governor will; or, if the load is suddenly thrown on to the engine, it will not increase the steam quite so fast as this form of mill-governor would. The effect of governing too fast is sometimes bad, because of the steam of the parts with too great a head of steam on.

793 Q. Do you understand this thing as described to govern very rapidly in this book?

A. It is, sir.

794 Q. Taking this drawing as descriptive of the machine, what is your opinion about the practical operation of that engine?

A. I have no doubt it would work very well—that it is a re-

markably good and well-planned engine. I only see one thing I would alter: that is, I would try and get the exhaust valves a little nearer to the cylinder than the Frenchman has put them: but that would not affect the question of regulation at all. In the 5th vol. of *De Armengand* he states that the subject of this application
353 of the governor to the cut-off valve is occupying great attention; and he says: "We will give very soon the different forms of this mechanism of the variable cut-off, and principally that applied to the form of valve called the Cornish valve, having an equilibrium of pressure." Now, this engine, described in the next volume, is one working under an equilibrium of pressure, having the Cornish valve, or a particular kind of balance valve, described on page 12.

795 Q. Explain what is the mill-governor, as distinguished from the fly-ball or any other governor; secondly, how it operates; and thirdly, why it produces a certain perfection.

A. In the ordinary fly-ball governor, if the engine is going fast, the balls rise; if the engine is going slow, the balls fall. Now, suppose that this engine is moving with the balls in any given position, and cutting off at half stroke, and suppose, then, that a little more than half the load is thrown off, the engine then will only need to cut off at $\frac{1}{4}$ stroke; but, in order that it should cut off at $\frac{1}{4}$ stroke, these balls must stand higher up than they were when the engine was cutting off at half stroke, so that, by means of this form of governor, you never can get perfect regulation, for the reason that when the load is thrown off the engine must make more turns a minute than when the load is on. The difficulty exists that the engine cannot move under a small load unless it runs at a higher velocity than that at which it runs under a great load. I may repeat that the speed of the engine determines the position of these balls. Now, by means of using the mill governor, no matter whether the load on the engine be great or small, the engine always works itself back again to precisely the same velocity, which is a perfection of regulation that cannot be found in the ordinary fly-ball governor.

796 Q. In *this* case is the position of the governor and the position of the valves tied together?

A. No. In this [the mill-governor] the position of the governor and the position of the valves are not dependent upon one another: but in the common fly-ball governor the position of the governor and of the valves are dependent on one another. I speak with reference to the quantity of the opening. That engine [with a fly-ball
354 governor] must always go above its average speed when the load is light, and always below the average speed when the load is heavy; whereas, in this engine with a mill-governor, no matter whether the load is heavy or light, it screws itself back to the same speed. The load of the engine as it varies requires greater or less amount of opening of the valves if you regulate by variable cut-off.

797 Q. Suppose the engine to have the load thrown off entirely, it requires only enough steam to overcome the friction of the machinery?

A. That is all, sir—the machinery and the shafting.

798 Q. Take the case of an engine which requires the steam to be cut off at $\frac{1}{4}$ the stroke when it is doing its ordinary load. At that velocity the governor balls stand at a certain height, making the cut-off valve close at $\frac{1}{4}$. Could they cut off close at $\frac{1}{4}$ with the balls in any other position?

A. No, sir; it cannot with that fly-ball governor.

799 Q. Then, if the engine has all its load thrown off, we well say it is required to reduce the cut-off to $\frac{1}{20}$ to keep it going?

A. Then, if you have the common fly-ball governor, the balls must occupy a higher position, which shows that the engine is going faster.

800 Q. Can they put the valve to cut off at $\frac{1}{6}$, and yet the balls remain in the same position as when they cut off at $\frac{1}{4}$?

A. No; the engine must run faster. But that has been reduced by proper proportions of the parts, and the governor within a very few revolutions per minute.

801 Q. It is practically good enough?

A. Yes.

802 Q. How in the French machine. Is that practically good enough?

A. Yes, sir. In this French machine, supposing that to be the position of the governor, in which neither of these cog-wheels are touching, [illustrating,] and the balls to revolve in that plane at 60 turns a minute, no matter whether the engine cuts off at $\frac{1}{20}$ or at full stroke, it will do it with the balls in the same position.

355 803 Q. Your engine is now running at 60 revolutions a minute; the balls will occupy that position and no other. Now we will throw off the whole load.

A. If you throw off the whole load then the balls will rise and put this screw in action, and by screwing the engine down it cuts off short until it comes to 60 revolutions. Then these occupy the same place, and the governor does nothing until they start again.

804 Q. Suppose the load to be thrown off and the balls thrown up, she goes faster?

A. She must go faster.

805 Q. Keep the balls up and she will go on till she takes no steam at all?

A. Yes, sir.

806 Q. The engine not taking steam, she will begin to go slower?

A. She will with the common fly-ball governor. Then the balls will drop and give steam. Then the balls will go up again.

807 Q. To count the runs a minute it might not make a large variation, but how would it affect the nicety of the speed within any two or four revolutions?

A. I can only say that all this talk about precision of regulation I consider very fallacious. It may not vary more than two turns in a minute, and you might believe from that that she only varied a small part of her speed; but that variation of one turn is often effected in two turns of the engine, so that the engine may vary 30 or 40 per

cent. from her speed, and yet the average may be within two revolutions a minute.

808 Q. How on this form of regulation, [the mill-governor?]

A. There will be perturbations in that also, but it screws itself back to the same speed, and leaves itself there.

809 Q. Explain what is a mill-governor, as distinguished from a fly-ball governor.

A. The governor of this machine is this whole arrangement, commencing with the fly-balls and ending with the rod and the sleeve, which you find in the usual fly-ball governor, which changes the position of the cam port of the machine, so as to regulate its speed. This whole apparatus from my right hand to my left is the mill-governor.

356 810 Q. That is a separate machine, well known as the governor?

A. Yes, sir; it has been applied to everything, almost, from a horse-power upward.

811 Q. That governor has been well known as a machine distinct from all other forms?

A. It is, sir.

812 Q. Suppose you take out of the mill-governor so much as is above my hand, what is that?

A. Then you have a common fly-ball governor.

813 Q. Can you take any part out of that without destroying its operation as a mill-governor?

A. You cannot take any part out without destroying its operation as a mill-governor; but if you take out the part which makes the mill-governor, and instead of the upper pinion substitute the sleeve, you come back to the common fly-ball governor.

814 Q. The water-governor you spoke of, can it be used in this organization?

A. It can. I have seen water-governors applied to steam-engines.

815 Q. Do you know any form of governor, that you now think of, that is not capable of regulating steam-engines by any of the methods?

A. I do not know of any except the Vane governor, acting by the resistance of the air.

816 Q. What is your opinion on the question, whether it requires any invention in this organization to substitute one for another of the various forms of cut-off to operate the cut-off.

A. Take it as a general question, I should say it did not; there may be instances in which it does.

817 Q. Take the case of the fly-ball governor?

A. It would be but a mere change of one well-known part of a combination for another part. There may be some forms of governor that would require invention, or they might be put in such a way as to require invention. There are plates in this book with both fly-ball and mill-governor, and I should think it required no invention to substitute a fly-ball governor for a mill-governor.

818 Q. You have heard, perhaps, the description that has
357 been read here from the patent granted to Zachariah Allen?

A. I am familiar with that patent. I became familiar with it while I was examiner in the Patent Office.

819 Q. Explain to the court what kind of valve gear that was, and what kind of operation it had, and what difference there is between these two things?

A. There is described in that patent a form of governor which I gather from the whole description to be a mill-governor attached to a liberating valve gear; the valve gear being of the cam variety, and the valve which is acted upon being what is known as the expansive valve, or valve outside of the main steam valve. It differs formally from the machine described in Tredgold, in the fact that the instrumentality applied to move the cam is a mill-governor instead of the common fly-ball-governor, and that the expansion valve in Allen's machine is what is commonly known as the wing valve, while in the Tredgold machine the expansion valve is a balance puppet valve. The wing valve was something like the old wing throttle; that valve was thrown open by a cam, and when the valve passed the tail of the lever which opened it, a spring threw it violently back again into its seat, causing a quick cut off.

820 Q. That was a liberating valve gear?

A. According to the definition given of what a liberating valve gear is, one in which the valve is lifted by the power of the engine and returned to its seat by gravity or a spring.

821 Q. Is there any advantage that results from the combination of the governor with liberating valve gear, that you know of, which is not described by Allen in his patent?

A. I do not remember his whole description, but he shows a machine which embodies all the advantages. I know he knew very well what he was talking about. I often admired the patent as an admirable production for the time it was drawn up, in 1834. He states he is fully acquainted with all the difficulties of regulation by connecting the mill-governor or regulator with the usual throttle valve. He then states that greater economy can be obtained by applying the governor to regulate the period of cut off; and
358 after that he states how the governor can be applied to regulate the period of cut off.

822 Q. His method of regulating valve gear, or the motion of steam-engines, is that substantially the same or substantially different from the method exhibited in the plaintiff's, defendant's, French, Tredgold's, and others?

A. As a method of regulating engines by determining the period of dropping the valves, or cutting off the steam by the action of the governor, it is the same in them all—the plaintiff's, defendants, the French engine, Tredgold's, and two or three other French engines in the books referred to.

823 Q. In respect to the advantages which result from the particular plan of operation exhibited in the plaintiff's, the defendant's, and the French machine, as compared with the plan on Allen's ma-

chine, state wherein consists the advantage of those over that; is it in method of regulation or in anything else?

A. The plaintiff's, the defendant's, and the French machines are not better than Allen's, as a method of regulation, but they are better in the fact that they make the cut off nearer to the cylinder; they leave less clearance between the cut-off valve and the piston.

824 Q. What is the result?

A. That you will get from all your steam both its force on entering by pressure, and its force by expansion; whereas if you cut off outside the mean steam valve only a portion acts by pressure.

825 Q. In respect to regulation?

A. They are the same.

826 Q. State how they work more accurately than the other.

A. I do not think there would be any difference, as a mode of regulation, whether it regulate the time at which an expansion valve should be dropped, or the time at which the main steam valve itself should be dropped.

827 Q. In respect of economy?

A. In respect of economy the advantage is in favor of the steam valve.

828 Q. Would that be true, whether with a fixed or a variable cut-off.

359 A. It would be true, whether cutting off by the governor, or affixed cut-off, or variable, by the hand of the operator.

829 Q. That economy does not depend on the fact of automatic regulation?

A. It has nothing to do with that fact at all.

830 Q. We have heard some witnesses testify about the substitution of an engine by Mr. Corliss for other forms. As steamboat inspector, what is your experience in respect to the tightness of valves, and the condition of engines, as they have been ran and used?

[Mr. Curtis objected.]

Court: Confine the question to the defendant's and plaintiff's.

831 Q. Then in respect to the facts submitted by one of the witnesses, Mr. Stearns, he testified that his engine was running with a cut off at the length of ten inches out of six feet stroke for the maximum load, and that it varied under the conditions of his varying load down as low as four inches?

[Court: He stated between two and three, or eight and ten inches.]

832 Q. Mr. Dickerson: He also said he made the variations of the load about fifteen minutes for twice a day, when he threw off a certain amount of the load; he stated it was a high-pressure non-condensing engine. Now, suppose that engine to have had the cut off fixed at ten inches, which was his maximum cut off, and to have had a proper register throttle valve, and regulated that way under the conditions there stated, what effect do you suppose would be possible in respect to economy of fuel, the load of steam being eighty-five pounds?

A. I have not the books to calculate it exactly, but I can speak of what would be the result. When working at ten inches, with eighty-

five pounds, she would be working at the best possible point;
360 when he cut off below that he lost by cutting off, and if he had attached his governor fast to his throttle valve he would have saved that loss. If he only threw off his load for fifteen minutes twice a day the saving would be a very small one; it would be in favor of using the throttle valve under that state of facts.

833 Q. That is a thing susceptible of demonstration?

A. Yes, sir.

834 Q. Now, in regard to this matter of economy, which has been suggested, in an engine running ordinary machinery, is there any economy, practically speaking, in regulating by the governor in place of by the cut-off?

A. There might be instances in which it would be most economical to regulate by the cut-off; there might be others in which it would be most economical to regulate by the throttle valve; and there might be other instances in which it would be hardly possible to distinguish between the two. It would depend upon the maximum period of cut off, upon the quantity and variations of the load, through what time it was carried, and the pressure of steam in the boiler.

835 Q. Considered in the light that engines are now generally made to cut off at about one-eighth of the stroke when doing their regular work?

A. If cutting off at about one-eighth, and then able to carry the whole of their load under a pressure of seventy-five to ninety pounds, in those cases the governor applied to the throttle valve would be more economical than the governor applied to the cut-off.

836 Q. Then there are other advantages of applying the governor to the cut-off independent of economy?

A. Yes, sir.

837 Q. Now the manner in which an engine operates, economically considered, is proved by the indicator card?

A. It is to some extent, but not always. The indicator card will prove always if the valve or valve gear is in bad order; but there may be leaks about an engine through which serious loss indeed may be incurred, which the card itself will not discover.

838 Q. But by the card, with the quantity of fuel burned, and a knowledge of the evaporation of the water, you can find out the whole story?

361 A. Yes, sir; you often find out that an engine which was supposed to be in good order is in bad order. The water leaks. I have seen streams of water go through the valves as big as my leg when it was supposed they were in good order.

839 Q. You have seen the card sworn to by Mr. Holland. So far as that card of the *Augusta* is concerned, what do you say about the perfection of the machinery?

A. It is as good a card as I ever say in my life. I have seen cards within four per cent. of the whole useful effect got by the engine—a Sickles' cut-off card from the *Baltic*—and I should say this card was

fully as good as that. The card is very nearly theoretically correct—almost exactly.

840 Judge Shipman: We are very anxious to get at the essential distinction you make between the machine of Corliss and the defendant's. In the first place, I understand you to say that the plaintiff's machine and the defendant's both have a fly-ball governor, and both have a liberating valve gear?

A. Yes, sir.

841 Q. That the governor or regulator is connected with a third instrument, to wit: the gauge bar here, and helical cam there?

A. Yes, sir.

842 Q. That the third instrument to which the governor in each instance is connected fixes the time at which liberation takes place?

A. Yes, sir; the same as in this engine.

843 Q. But that liberation, in point of fact, is effected in one instance by the power of the engine, and in the other by the helical cam?

A. In one by the relative motion of the parts, but in the other instance by the helical cam.

844 Q. You make the machines identical until you come to the force which detaches the parts?

A. Yes, sir; until you come to the distinction between this old French cam here and the Sickles valve gear.

845 Q. If I get at the point it is, that in the Corliss machine the act of detachment is effected by the cam?

362 A. Yes, sir; the cam is obliged to come into play to operate the detachment.

846 Q. And in the defendant's machine the time when that detachment is to take place is fixed by the governor as well as in Mr. Corliss'?

A. Yes, sir; in all. Detachment is performed in Mr. Corliss' by the third instrument, and in the defendant's by the relative position of the parts.

847 Q. That is the essential distinction which you make?

A. Yes, sir; between one class of valve gear and the other.

848 Q. Mr. Corliss' machine fixes, by the instrument connected with the governor, the time when detachment takes place, and causes the detachment itself; but in the defendant's machine it fixes the time, and leaves the act of detachment to be made by the motion of the other parts?

A. Yes, sir.

849 Q. [By Mr. Dickerson.] And that distinction is one which is peculiar to the valve gear, and not to the combination of the governor with the valve gear?

A. That is a distinction which is peculiar to the valve gear itself, whether the governor be there or not.

850 Q. One is called the trip cut-off which has this detachable quality in it, and the other is the liberating valve gear?

A. Yes, sir.

851 Judge Nelson: I presume the answer of Mr. Renwick includes

the French machine, and assumes the idea that the arrangements by which the regulator reaches the operation of the cut-off upon the valve are the same with the plaintiff's. You say so far as regards the regulation of the governor in the plaintiff's to fix the time for cutting off, that is common with the French machine?

A. Yes, sir; and with the defendant's also.

852 Q. You assume that this arrangement in the French machine to produce the result is the same as in the plaintiff's?

A. I do not think there is any difference in the arrangement?

363 853 Q. What do you call the third instrument in the plaintiff's machine?

A. The helical cam, which actually knocks it out.

854 Q. Does it not *there* also?

A. No, sir; the cam disengages itself. [Illustrates.] In the French machine suppose there is no governor upon it at all. Now the cam comes round and lifts the valve. Now as this part tends to move in this direction, and that part in that, there is a separation effected without the instrumentality of *that* and the valve drops. There is nothing required to let these two parts separate and let gravity act. That peculiarity of action is found in the French machine. Now there is an instrument in the French machine and in the defendant's machine which defines the position of this cam in the French machine and the tappet in defendant's; and there is a yoke in the French machine to regulate the period of cut off. But there is an instrument in the plaintiff's machine, when it acts, that effects a separation. Suppose when this cam got there, this roller could not get away from it, a third instrument comes in and knocks it away. That is the third instrument in Corliss' patent, that helical cam. You see *this* hook here drops into *this* socket, and holds the two together. Take this helical cam out of the road, and you may move these two forward and backward forever, and they will not be parted. That is not true in the French engine, because if you move the cam and the tail of the lever they will part. They will not part in Mr. Corliss' unless this helical cam comes round and knocks the latch out. In the machine minutely described in Mr. Corliss' patent, you must have a third instrument. In the French machine the parts separate of necessity, and the valve is permitted to drop by gravity.

855 Q. [By Mr. Dickerson.] Is there anything described in this patent of Mr. Corliss' which suggests any other method of liberation, as contemplated by him, than the kind known as the trip cut-off?

A. I think there is, sir; most decidedly. I think he suggests my method of liberating.

364 856 Q. I speak of the special description of one of the variations of valve gear, and the alternates of that peculiar valve gear.

A. In the valve gear minutely described by him there is an instrumentality which knocks out the watch. In the original patent there was described an instrument, besides the helical cam, which might take the place of the helical cam, provided it performed the same duty as equivalent.

fully as good as that. The card is very nearly theoretically correct—almost exactly.

840 Judge Shipman: We are very anxious to get at the essential distinction you make between the machine of Corliss and the defendant's. In the first place, I understand you to say that the plaintiff's machine and the defendant's both have a fly-ball governor, and both have a liberating valve gear?

A. Yes, sir.

841 Q. That the governor or regulator is connected with a third instrument, to wit: the gauge bar here, and helical cam there?

A. Yes, sir.

842 Q. That the third instrument to which the governor in each instance is connected fixes the time at which liberation takes place?

A. Yes, sir; the same as in this engine.

843 Q. But that liberation, in point of fact, is effected in one instance by the power of the engine, and in the other by the helical cam?

A. In one by the relative motion of the parts, but in the other instance by the helical cam.

844 Q. You make the machines identical until you come to the force which detaches the parts?

A. Yes, sir; until you come to the distinction between this old French cam here and the Sickles valve gear.

845 Q. If I get at the point it is, that in the Corliss machine the act of detachment is effected by the cam?

362 A. Yes, sir; the cam is obliged to come into play to operate the detachment.

846 Q. And in the defendant's machine the time when that detachment is to take place is fixed by the governor as well as in Mr. Corliss'?

A. Yes, sir; in all. Detachment is performed in Mr. Corliss' by the third instrument, and in the defendant's by the relative position of the parts.

847 Q. That is the essential distinction which you make?

A. Yes, sir; between one class of valve gear and the other.

848 Q. Mr. Corliss' machine fixes, by the instrument connected with the governor, the time when detachment takes place, and causes the detachment itself; but in the defendant's machine it fixes the time, and leaves the act of detachment to be made by the motion of the other parts?

A. Yes, sir.

849 Q. [By Mr. Dickerson.] And that distinction is one which is peculiar to the valve gear, and not to the combination of the governor with the valve gear?

A. That is a distinction which is peculiar to the valve gear itself, whether the governor be there or not.

850 Q. One is called the trip cut-off which has this detachable quality in it, and the other is the liberating valve gear?

A. Yes, sir.

851 Judge Nelson: I presume the answer of Mr. Renwick includes

the French machine, and assumes the idea that the arrangements by which the regulator reaches the operation of the cut-off upon the valve are the same with the plaintiff's. You say so far as regards the regulation of the governor in the plaintiff's to fix the time for cutting off, that is common with the French machine?

A. Yes, sir; and with the defendant's also.

852 Q. You assume that this arrangement in the French machine to produce the result is the same as in the plaintiff's?

A. I do not think there is any difference in the arrangement?

363 853 Q. What do you call the third instrument in the plaintiff's machine?

A. The helical cam, which actually knocks it out.

854 Q. Does it not *there* also?

A. No, sir; the cam disengages itself. [Illustrates.] In the French machine suppose there is no governor upon it at all. Now the cam comes round and lifts the valve. Now as this part tends to move in this direction, and that part in that, there is a separation effected without the instrumentality of *that* and the valve drops. There is nothing required to let these two parts separate and let gravity act. That peculiarity of action is found in the French machine. Now there is an instrument in the French machine and in the defendant's machine which defines the position of this cam in the French machine and the tappet in defendant's; and there is a yoke in the French machine to regulate the period of cut off. But there is an instrument in the plaintiff's machine, when it acts, that effects a separation. Suppose when this cam got there, this roller could not get away from it, a third instrument comes in and knocks it away. That is the third instrument in Corliss' patent, that helical cam. You see *this* hook here drops into *this* socket, and holds the two together. Take this helical cam out of the road, and you may move these two forward and backward forever, and they will not be parted. That is not true in the French engine, because if you move the cam and the tail of the lever they will part. They will not part in Mr. Corliss' unless this helical cam comes round and knocks the latch out. In the machine minutely described in Mr. Corliss' patent, you must have a third instrument. In the French machine the parts separate of necessity, and the valve is permitted to drop by gravity.

855 Q. [By Mr. Dickerson.] Is there anything described in this patent of Mr. Corliss' which suggests any other method of liberation, as contemplated by him, than the kind known as the trip cut-off?

A. I think there is, sir; most decidedly. I think he suggests my method of liberating.

364 856 Q. I speak of the special description of one of the variations of valve gear, and the alternates of that peculiar valve gear.

A. In the valve gear minutely described by him there is an instrumentality which knocks out the watch. In the original patent there was described an instrument, besides the helical cam, which might take the place of the helical cam, provided it performed the same duty as equivalent.

857 Q. Look at the paragraph preceding the claim: In the form of steam-engine "delineated by fig. 2, the periods of liberating the valves may be varied by wedge-formed stops or cams substituted for the helical cams, and connected with the slide of the regulator, which in that case should not turn; cam-shaped or other forms of stops may be connected with the slide of the regulator by levers, so as to be moved in the plane of motion of the valve mechanism in such directions as to vary the periods of liberating one portion of that mechanism from the other." Do you find in that any suggestion of any instrument, other than the helical cam, or some equivalent, performing the same functions?

A. No, sir; I find the equivalent of the helical cam suggested for liberating the latch.

858 Q. Refer to page 18, lines 5 to 11, and the drawing to which he refers.

A. That is a statement of the way of moving the valves, not a statement of how any different kind of stops can be used to make the liberation. After line 10, he states: "I wish to be distinctly understood that in the mode of regulating the cut-off by the governor, I do not limit myself to the use of the particular kind of cam described or represented, as the form, position, and operation of these may be greatly varied without changing the principle of this part of my invention; as, for instance, stops or cams connected with the slide of the governor by levers, may be made to slide in the direction of the plane of motion of the valve rods, to vary the periods of liberating the catches of the valve rods; or wedge-formed stops or cams may be substituted for the helical cams, and attached to the cam rod, which in that case must not turn."

859 Q. Is there anything in these suggestions of any other
365 than the cam or stop which you have called the third instrument?

A. There is no suggestion of anything which will not perform the office of knocking open the latch, and effecting the disconnection, which is called the third instrument?

860 Q. I will now call your attention to the reissued patent, No. 780. Have you examined that patent, and do you understand the machinery there described and its operation?

A. Yes, sir.

861 Q. I call your attention to line 40. "The blocks *(u u)* for the two valves are secured to a sliding rod *(y,)* and the latter may be connected with the governor at *(r)* to determine by the velocity of the engine the position of the gauge bars, and hence determine the distance to which the shoulders on the spring bars may be forced outward by the springs." Is there any such operation on the machine which is described and exhibited in the drawings and model of the machine in that patent?

A. There is not, sir. You never can open the valve at all if you do not permit the shoulders to engage.

862 Q. Is that description I have read at line 40 descriptive of the operation on this (pl'ff's) engine?

A. It is not, sir.

863 Q. Refer to the patent of Green, page 23, line 40: "Or instead of this, the stem may be connected with the governor, to determine by the velocity of the engine the position of the gauge bar, and hence the height to which the tappets may be forced up by the spring, which will determine the period of closing the valves." Is that a correct description of Green's engine?

A. It is, sir.

864 Q. Describe that on the model.

A. [Illustrating.] *Here* on Corliss' is what is termed in the patent a sliding rod. There is a shoulder on that spoken of in the patent. There is also another shoulder on *here* which will return the valve to its seat, in case it does not drop, but sticks up. All mention of that shoulder is omitted in the present reissue. In the operation of this machine, this shoulder and the end of this lever are attached over there. The valve is going to begin to open, and as this wrist
366 plate moves in this direction it carries the end of this rod to the right and downward. By virtue of the motion downward it opens the valve; and by virtue of the motion to the right it causes the cam to impinge against this rod, which becomes a fulcrum, and throws the end of this rod off, to effect disconnection. This [the rod] is the instrument which effects disconnection, and if this instrument were out of the way, disconnection would not be effected. In the original patent this was correctly described, but it is not now described that the position of this stop effects the distance to which this shoulder shall drop over the pin and thereby effect the disconnection. No such operation as is now described in the patent can take place, for the shoulder must be always thrown on to the full extent by the spring, or the engine will not cut off at all.

865 Q. [By Mr. Curtis.] Is there not a period there when that does determine the depth of the hold?

A. No, sir; not in the plaintiff's. In the defendant's machine it does effect the distance of engagement.

866 Q. [By Mr. Dickerson.] Be good enough to show what is meant by a gauge bar, as in the defendant's.

A. It is really a gauge bar. After the engine has thrown the tappet down and wound up the spring fully, the gauge bar regulates the distance to which this tappet should rise, and regulates the amount of hold it shall have on the valve lever. But in *this* one [Corliss'] it does not regulate the depth of engagement.

867 Q. [By the court.] As I understand you, the plaintiff's will not work as described?

A. No, sir; not practically.

868 Q. Your objection is not so far as regards the mechanical arrangement as described in the patent of the plaintiff, but you say it will not work?

A. The mechanical arrangement, as described in the plaintiff's patent, will work, and will work well, according to the way it is described in the old patent; but it will not work as described in the reissue. There is a false description in the reissue.

367 869 Q. Do you say it is not constructed according to the description?

A. It is constructed according to the description.

870. Court, [to Mr. Keller:] I understand you to admit that the arrangement here which Mr. Renwick has been pointing out in the plaintiff's machine was described in the old patent, and is found in the drawing?

Mr. K. Yes, sir.

871. Court: And I understand it is also described in the reissued patent?

Mr. Keller: The arrangement is described.

872. Court: Then the model as made is in conformity with the description of the plaintiff in the old patent and in the reissued patent. That being so, I do not see that you can take any objection to it, except that it will not work; because if Green's is the same, Green's is the junior.

Mr. Keller: After describing the particular construction, the plaintiff describes the manner in which it operates; and instead of describing it as operating in the actual way it does, he describes it as operating in Green's way, which it will not do.

Adjourned to 9 o'clock to-morrow.

TUESDAY, *Sept.* 25, 1860.

The court met at 9 o'clock a. m.

Henry B. Renwick's direct examination was resumed by Mr. Dickerson.

873 Q. Explain to the court the mode of operation of the machine described in the patent No. 780.

A. In the machine described in patent 780 (limiting myself to steam valves, as all there is a question about) there are two rocking and liberating arms—one for each of the steam valves. Each of these rocking arms is provided near its end with two shoulders—one shoulder to open the valve and the other to return the valve to its seat. Each steam valve in the machine is bolted fast to its

368 stem, the vibrating lever by which it is opened, and also shut by a weight attached to this rod. A motion in two directions to the reciprocating or vibrating rod is given to this instrument, called the wrist plate, and the motion of that wrist plate is derived from the motion of the main shaft of the engine. There are also for each steam valve two springs, which always tend to force the end of these reciprocating and vibrating levers in contact with a pin on the end of the levers. There is also for each steam valve what is called a stop, which can be set out and in at varying distances, as described in the patent, either by the hand of the engineer or by the governor. Now the operation of the machine is this: The valve being hooked on (take the upper valve, where the hook has engaged itself with the pin by means of this spring) after the hook is engaged you will notice that the first motion of the end of this reciprocating and liberating lever which is attached to the rock shaft is towards a line joining the valve stem; and if anything were interposed, so as to make that reciprocating rod act as a lever,

and oscillate on the centre, that interposition would cause one end of the rod to travel in a different direction from the other, and unhook it off the pin and permit the valve to drop. The real operation of the machine is the hook always takes hold of this pin at the time the valve is upon its seat. It then continues to lift the valve until such time as some part of this reciprocating and vibrating rod strikes this stop, which is a fulcrum of the lever, and which effects the disconnection. When it strikes the stop the motion of the first end of the reciprocating rod throws the other end in an opposite direction and unhooks the valve, so as to permit it to drop. The time of liberation of the valve depends upon the time at which this stop comes into action. That stop represents what I call the third instrument, in speaking of the other machine of Corliss', (his original patent,) which is necessary to effect the disengagement of the two parts of the valve gear. Those two parts in this instance being the vibrating lever attached to the valve gear and the oscillating reciprocating lever attached to the wrist plate; for if the centre of this lever never bears on the stop or rod to effect the disconnection the disconnection will not be made. It will work full stroke and return the valve to its seat. Now, in all the machines I have seen work, made in accordance with this patent and in the model and drawings I have seen, this hook always hooks itself to its whole distance on to the pin, and your honor will notice that the shoulder of the hook which does the work is a very small one. Now, the original patent describes this mode of operation—that this stop acts as a fulcrum, and, by coming into action sooner or later, effects the disconnection. The present patent states that that lever, instead of coming into action sooner or later, and effecting the disconnection by that means, on the contrary asserts that the lever permits the shoulder to engage to a greater or less depth. Suppose the full line [referring to a sketch] to be an engagement of the shoulder to half the depth, and the dotted line an engagement of the shoulder to the full depth—the present patent asserts that that is the mode of operation.

369

874 Q. [By Mr. Stoughton.] I understand you to say the present patent asserts that the stop or cam determines the extent to which the shoulder should engage?

A. Yes. The statement in the patent is: "The blocks (u u) for the two valves are secured to a sliding rod (y,) and the latter may be connected with the governor at (r) to determine by the velocity of the engine the position of the gauge bars." Now in this patent these stops are for the first time called gauge bars. "And hence determine the distance to which the shoulders on the spring bars may be forced outward by the springs;" that is, that the position of the gauge bars will determine the distance to which the shoulders on the gauge bars may be forced outward by the springs, which will determine the period of closing the valves. Now what is it that will determine the period of closing the valves? The distance to which the shoulders of the gauge bars may be forced outward will determine the period of closing the valve.

875 Q. [By Mr. Dickerson.] Now turn to page 21 of the exhibits, the original patent, line 52.

A. It is here correctly described. These rods, one for each valve, which I have my hand upon, which are called spring bars in the present patent, are called in the original patent, what they
370 really are, "lifting rods." [Reads from original patent.] The meaning of that is that if this lifting rod did not have the motion which enabled it to pry itself off by means of this stop, but on the contrary moved in straight lines, so that there was no tendency to pry it off, then he says some other instrument, moved by the engine, should come in and effect the disconnection, when the valve would drop. [Illustrates by model Y.] Suppose, if your honor please, that *this* was the lifting rod of that engine, and *this* was the part attached to the valve gear. As long as that moves in straight lines there would be no detachment effected; but in case they do move in straight lines, he says then some instrument must come into play and knock the rod out of place to effect disengagement. That instrument would be, to a certain extent, an equivalent to the stop, because the active agent of disengagement.

876 Q. That active agent you speak of is what you call the third instrument?

A. Yes, sir.

877. Now, this patent describes the machine to be independent of regulation; that is, whether the gauge bar be regulated by cut off or by hand. On line 45 of patent 780: "In the present instance the sliding rod *(y)* is represented as moved through the intervention of a rack *(u)* and worm *(p.)* This is intended for hand adjustment. The rack and worm are dispensed with when the governor is applied." This is a machine independent of that governor contrivance?

A. Yes, sir.

878. Now, when this valve gear [Corliss' 2d patent reissue] is used at a set position; that is, set by hand, and you take away the gauge-bar, what happens then?

A. Then it happens that it is not a liberating valve gear. Suppose the stop taken out of the machine, or shoved back so far that it does not act, it is no longer a liberating valve gear; it is (except with some peculiarity of arrangement) an ordinary full stroke valve gear like that on any old-fashioned engine moved by means of the eccentric hook and rocking lever.

879 Q. Now, in the machine of Mr. Green, will you explain
371 to the court the operation of that thing called the gauge bar?

A. The stop is now taken out of the defendant's machine, and it will always act as a liberating valve gear. It cannot act in any other way.

880 Q. Now, suppose they want to cut off at any particular cut off?

A. They can be set by hand. It always cuts off whether the stop is there or not and always liberates. It is a necessity of the machine that the valve gear must liberate. If it does not liberate, but still keeps in contact, both valves would be open at once, and all the steam going into the engine at one end would run out through the other.

881. Look at the thing described at line 57 of patent 780: "Combining with the rocking levers or their equivalents for operating

the valves, the shoulders on the spring bars, or their equivalents," &c. Tell the court what the thing that is described is, in this first claim.

A. The thing described there is also described at line 19, where he says: "This part of my invention consists in combining with the levers that operate the valves, the shoulders on the spring bars, the said shoulders being borne towards the axis of the levers by the force of gravity or springs."

That mechanism, taken by itself without the stop, not embraced under that head, is merely an instrument for opening the valve at the proper time by means of a hook on the vibrating rod. Both shoulders are not spoken of by the claim, so that the hook would not return the valve to its seat in case the gravity failed. It is merely a mechanism for opening the valve.

882 Q. Look at the description in Exhibit L, line 37: "These lifting rods terminate in hooks *i i*, which engage with the toes *o o* of the rock shaft arms, and are kept engaged with them by springs j j, which bear upon the backs of the lifting rods." How are they described in the patent? Are they described with shoulders on both sides?

A. I do not see that statement here [reissued patent.] He *there* [Ex. L] describes the machine exactly as it is; that is, if the
372 stop be taken out and the spring bar and hook be in contact with the end of the toe, then the steam valve will be opened and closed at full stroke, and no disconnection take place.

883 Q. Is there anything new about that contrivance?

A. No; that is substantially the same thing as the old-fashioned eccentric hook and rocking lever that has been used for 100 years?

884 Q. (By Mr. Stoughton:) What is that?

A. I say that, so far as it is a mechanical combination of an eccentric rod and reciprocating lever for opening the valve and permitting it to shut by gravity, it is nothing more than the old eccentric hook and rock shaft, known for 100 years, or more. In this engine [referring to model] the eccentric hook with two shoulders—the rocking lever which actuates the valve—that part of the engine is very old and of well-known form. You notice that as that shoulder moves acting against the pin in the end of that lever it lifts this steam valve, and if no disconnection is effected it permits that steam valve to return to its seat by the force of gravity, as that does in the other case [Corliss'] if no disconnection is made. And this (the old one) also has the same capability of making disconnection. If some active agent were to carry this rod in the old engine to one side, what Mr. Corliss describes as the disconnection would take place, and the valve drop to its place. So that this lever and hook on the old engine have all the peculiarities of the lever and hook on that machine of Corliss'.

885 Q. Refer to page 24, line 10, Green's patent, and state to the court what is that specific device.

A. The specific device in this patent consists, first, of a rod which moves coincident with the piston, and has very much the peculiarity of the old plug-frame arrangement. In Mr. Green's engine these

tappets are made into spring tappets, so that he can alter the time of disengagement by permitting them to jump up to a certain height, and also permit them to dodge back under the toes of the lever. There is a tappet on that old plug-tree, and when that tappet strikes against that lever it effects the disconnection and the valve is opened. When disconnected this other tappet bears
373 against the end of the rocking lever and returns the valve again to its seat—the motion being communicated through the means of tappets on the plug-tree, which is a reciprocating rod.

886 Q. These are in common use in engines?

A. I have seen them in common use in pumping engines.

887 Q. Now, in your opinion, are those things described to the court substantially the same or substantially different arrangements?

A. I think Green's is substantially a different arrangement both from the old eccentric hook and from the arrangement described in Mr. Corliss's patent, although both the arrangements described in Corliss', the old eccentric hook and Mr. Green's tappet, all three of them lift the valve by communicating motion to the end of the rocking lever; but the instant you depart from that point Mr. Green's is different from the old plug-tree; while Mr. Corliss', unless the stop is interposed, does nothing that is not done by the old eccentric hook. Mr. Green's is different both from the old arrangement and from Mr. Corliss'.

888 Q. Now, there is another claim set up in that patent: "In combination with the shoulders on the spring bars that operate the rocking levers, substantially as described, the employment of the gauge bars or any equivalent therefor to regulate the periods of closing the valves whether the said gauge bars be regulated by a governor or by other means, as set forth." If you look at Green's patent, page 24, you find there the same language used. What office does that little pin perform there on one end of the sliding bar placed over the hook? [refers to Corliss' brass model.]

A. It was to regulate the depth of engagement so as to determine the period of cut off.

889 Q. Is that the mode of operation described by the plaintiff's patent?

A. No; the alternative mode of operation described by the plaintiff's original patent is that, when the shoulders, by virtue of that rocking motion derived from the wrist plate will not unhook itself over the lever or when that reciprocating vibrating rod has not the vibrating motion given to it by the wrist plate, then some
374 instrument must be used which will throw the catch out of the way and effect the disengagement, such catch being moved by the engine.

890 Q. Look at *this* particular point: if the valve was made to operate *that* way the governor could operate upon the disengagement through the gauge bar only?

A. That is all, sir; it would have to operate upon it through the gauge bar.

891 Q. In that case it would be hampered through the whole time of connection?

A. It would, instead of being hampered only at the instant of falling, as in Mr. Corliss' invention, minutely described in his patent.

892 Q. You refer to the spring hook?

A. Yes; if the gauge bar determines the depth of engagement.

893 Q. Will you compare the two machines—the Greene machine and the Corliss machine—in respect to the matter in the second claim?

A. In the second claim Mr. Corliss described a hook, as I said before, having the same operation in opening and closing the valve as the common eccentric hook attached to the rocking lever and ordinary rock shaft; and that is stated there to act in combination with a stop, which acts as the fulcrum of the lever, and by means of a rod vibrating over that fulcrum a disengagement will be effected; and if the fulcrum be taken out of the way no disengagement will ever be made. That fulcrum is called, in the present patent, a gauge bar. That is the operation of that machine. In Greene's machine the disconnection between the tappet that strikes against the end of the valve lever and the end of the valve lever itself is effected without the operation of any fulcrum of the lever, or an equivalent for it; and the gauge bar has nothing to do with effecting the disengagement, as the disengagement will be effected while the gauge bar is out of the machine.

894 Q. Taking the element of the gauge bar in these two machines are they substantially the same machine?

A. They are substantially different. The two things called a gauge bar in both are instrumentalities which would perform different offices.

375 895 Q. In regard to regulating the period of closing the valve, do they perform the office in the two combinations in substantially the same manner?

A. No; one performs it by tripping the valve by a third instrument; the other, by effecting disengagement by a motion which will always trip the valve whether the gauge bar is there or not. The gauge bar [in Corliss'] when working with the governor is used to effect a disengagement of the tappets. *There* [in Greene's] by setting the tappets properly you cut off at the proper period of stroke without the gauge bar at all.

896 Q. Having got the machines in various forms before the court, I wish you to institute a comparison between these different machines—the plaintiff's, defendant's, and French machine—in respect to the particulars which have been the subject of these claims in the different patents.

A. Before going into that I would like to say a few words. I have not explained yet how each of these machines do actually work, and I found myself in difficulty last night from that fact. E is a correct model of the machine specifically described in the Corliss patent of 1849, and the first reissue.

897 Q. You mean the mechanical arrangement specifically described?

A. Yes. *Here* is a representation of the main shaft of the engine. *There* is the eccentric. *Here* is the eccentric rod. Here is what is commonly known as the intermediate shaft, communicating its motion

to the bell crank, and that bell crank takes hold of the slide which is attached by a rod to the valve. Now, the motion of the valves is such that this eccentric will always move that valve off its seat at the proper time, and will always return it over its seat at the proper time; provided there is nothing more in the machine than I have described. But now, between the eccentric and the valve there is made a socket and a latch. Now, when that latch is thrown out of that socket, then the valve gear will be in two parts, and will be a valve gear under the definition given in the patent—that is, where the valve is moved to open by a force derived from the engine, and is returned to its seat by the force of gravity or a spring; and it does not have that peculiarity until you have some connection capa-
376 ble of being separated somewhere between the valve and the eccentric. Now, there is put into this engine, for the purpose of regulation, a fly-ball governor, and what is called a helical cam on stops. That cam has a projection upon it shaped like a screw-thread, and the office of that cam is not to open the valve, nor is it to close the valve, because the valve is opened by the engine through the ordinary eccentric motion, and closed through the force of gravity. But the office of that cam is to knock out that latch, by striking against that projection, and to permit the valve to drop. That is what I call the third instrument. Suppose the part of valve gear attached to the eccentric one instrumentality, and the part attached to the valve the other, and the helical cam the third instrument which effects the disconnection. Now, as the governor raises the balls it brings this helical cam into different position, so that the disconnection is effected sooner or later.

898 Q. Depending upon the motion of the governor?

A. Yes, which keeps time with the motion of the engine. Now Mr. Corliss says, in his original and present patent, that the stop specifically described may have substituted for it certain other things. [Refers to walnut model.] A wedge-formed stop like this, not having a rotary motion, but operating to effect disconnection, and being the active agent to effect disconnection, will be the equivalent of the helical stop or cam. A straight stop may be made to perform the purpose. But still the stop would be the active instrumentality in effecting separation. Now, in the Corliss engine it results from these peculiarities that the governor has something to do; or, to speak more properly, the free action of the governor to lift and lower this stop is only impeded just at the instant that that latch is knocked out. You see that as long as that latch is not being knocked out the helical cam does not touch the latch at all; but just at the instant of knocking out the helical cam strikes the latch, and during that instant the free motion of the governor is hampered or impeded. You see in *this* no disconnection of the parts ever takes place unless this third agency for effecting the disconnection is employed, and by reason of this being the active agency the governer has this freedom of adapting itself to different positions.

377 899 Q. [By the court.] There can be no regulat on by the

governor of the steam unless you convert this motion in some way or mode with the liberation of the valve?

A. With the instrument that effects a liberation of the valve. But, generally speaking, going outside of this machine, unless you connect the governor with the instrument that effects the liberation of the valve.

900 Q. Because the very idea of regulating the steam by the governor necessarily connects it in some mode with its liberation from the operation of the eccentric?

A. Certainly. You cannot have any regulation by means of the cut-off unless the governor determines the point of disconnection.

901 Q. In all these machines, where you undertake to accomplish that purpose, to wit, to regulate the steam by the governor, it is only a different mode of machinery or a different contrivance in this connection of the moving power of the governor and that liberation?

A. That is all, sir. The governor, in all cases wherever the cut-off depends on the governor directly, determines the time of cut off.

902 Q. And as to different machinery it is a question of different arrangement?

A. Yes, sir, of different devices in that machine having different sub-effects, under the general effect.

Court: That is all. You may go on.

Witness: Now, in the French machine which I would like to go through a little more before comparing them: *here* is the cylinder of the engine; these two chests represent the two steam valve chests. These levers are the levers which lift the steam valve. They are open when in that position, and are shut by the force of gravity. And here is the main shaft of the engine, driven by the engine. The main shaft has a bevel wheel on it which drives the lower of *these* shafts as many revolutions as the engine runs. Now, upon this long rotating shaft there are two helical cams. One face—the straight face of these cams—in rotation strikes, at the proper time, one tail of *this* lever and lifts the valve. In the valve, as lifted *now*, the
378 engine is taking steam properly. At another part of the rotation the helical face of the cam slips by and the valve falls. Now, in addition to that, on this engine, there is what is called commonly the *mill-governor*, which is driven by the engine. That governor, if it rises too high, puts this endless screw in motion in one direction, because it hooks on to the lower side of this cog. If it falls too low, it moves the endless screw in another direction. The endless screw, if it falls too low, moves this sector of this rock shaft there, which is attached to *that* rod that carries two yokes on stops painted black. Now, as the screw, directed by the governor, moves this rod, this rod moves the yoke, and alters the position of the cam as you now see; shoves the cam in one direction on the other. If the governor balls rise, it shoves the cams in such a direction that the period of cut off is shorter. If the governor balls fall, it shoves the cam in such a direction that the period of cut off is longer. In this machine there is a liberating valve gear, so far as that valve is lifted by a power given directly by the engine and permitted to fall, by the

force of gravity, or a spring. *This* [taking up a large model] is a perfectly true representation of the cam in that French drawing; but it is not a perfectly true exemplification of the arrangement of valve lever. Your honors perceive that *this* cam is turned by the power of the engine; it comes against that roller and lifts the valve off its seat. When the valve roller comes to that part of the cam it tumbles off, and the valve drops to its seat by the force of gravity; so that, in the general sense, it is a liberating valve gear. Now, if the governor had pulled this cam in towards me the cut-off would be short. The valves would be open while that roller traveled from there to there; but supposing that the governor had shoved this cam out in *this* direction, as I explained, you see the cut-off would be longer; the valve would stand open a long time, and the engine would be working with more power. If it runs too fast it wants less power, and it is brought up to a short time of cut off again. In this form no third instrumentality is necessary to effect the liberation; the liberation takes place as a mater of necessity. But the governor in this French machine does determine the time at which the liberation will take place, because it determines the position of this cam.

379 Now, a few words as to the other machine. The Tredgold machine and two of the French machines have all the same peculiarity as this machine, in so far as that they regulate by the period of the drop of the cut-off valve; in so far as they effect that by means of the helical cam to lift the valve; in so far as they effect it by means of the valve falling to its seat by gravity or a spring when the helical cam leaves it; and in so far as the governor determines the position of the helical cam, and determines, therefore, the period of liberation of the valve. Now, they are all alike in that respect. They are different in the fact that *this* has an expansion valve outside of the main steam valve. The *Tredgold* one has the ordinary governor instead of the mill-governor; whereas, the Frenchman's differs from Tredgold in the fact that he moves the roller up and down instead of moving the cam up and down.

Now, in the defendant's machine there is a reciprocating projection, which acts against the *tail* of a lever, to lift the valve. That reciprocating connection passes by the tail of the lever, and the valve drops by the force of gravity; and disengagement, whether there be a stop or no stop, is a necessity of the continuance. In the defendant's engine there is what he also calls a gauge bar, which gauge bar regulates the distance of engagement of this stop. The gauge bar does not move the stop. The engine puts it in position, and the gauge bar only determines the position in which it shall be put.

903 Q. [By the court.] Of what you call the tappets?

A. Yes, sir; the gauge bar determines the position of the tappets. In the operation of this engine, when acting as a cut-off, controlled by the governor, the governor, as it does in all the engines before us, determines the period when the liberation shall take place. That they have all in common. But the governor in this engine does not set the position of the tappet; that is set by the engine itself. When

the tappet comes forward by the power of the engine, the power of the engine drives it down, compresses this spring below, and when the tappet gets on the other side, the spring, wound up by the engine, throws the tappet up into the place indicated by the gauge bar, acted
380 upon by the governor. It varies the period of cut-off, without any active instrumentality for effecting disconnection between these two parts of the valve gear, as a necessity of this machine. Now, to come to this difference of the machine No. 2. We have a valve gear the same in substance as that first model I had [model of patent 763] where the two parts of the valve gear are connected together by means of a catch, the one following the motions of the other all the time, opening and shutting the valve, except there be some active instrumentality interposed to break the connection; and we have an instrument which may be put in position by the action of the governor, by means of which instrument the governor determines the time of disengagement, that instrument also having the additional duty, besides determining the time of disengagement, of effecting the disengagement; and in so far in substance, it is like the machine described in the original patent, being a mechanical change more simple to use. I may say I have never seen a valve gear like that described on the black board in use.

904 Q. As to the experiment you made?

A. Mr. Copeland and myself made an experiment with the Green machine running at Pawtucket, R. I., to see whether the governor, through the instrumentality of the gauge bar, could effect the disconnection—that is, if it were possible, in the operation of the machine, that the gauge bar could be the active instrument in unlatching the two parts of the valve gear. We placed the engine with the valve slightly open (which was proved by the fact that she ran away once or twice;) we took the governor off the engine and loaded the top by screwing a board on the top to find out how much weight was necessary to depress the tappet at all. I think the weight was some 70 lbs. at all events. It was a far greater weight than the weight of the governor balls themselves; and of course the power to depress by the governor could not exceed the weight of its own balls.

905 Q. Can it ever equal them?

A. No.

906 Q. And the governor cannot effect any more force than the weight of its balls?

381 A. The weight of these balls, in dropping. I speak of its direct connection there. As I was going to say, to compare the defendant's engine with the French engine, and at the same time it may be compared with the Tredgold and the other French engines, for all are in the same category. In the defendant's and in the French engine the valve is opened by the striking of a tappet or the projection of a cam against the end of a rocking lever. They all have the same peculiarity. After the tappet or projection of a cam passes by the tail of the rocking lever, the valve drops by gravity. They all have that peculiarity. In all of them there is a governor to direct the period of dropping. I am excluding the plaintiff's. In all of

them the governor puts in motion, either itself or through some other instrumentality, the yoke or stop which decides how much surface of the cam in one place, or the tappet in the other, shall travel in contact with the end of the valve lever, during the time the valve is up; and in all of them the governor is hampered or impeded in its motion during the time the valve is remaining open. They all of them effect regulation by means of the governor acting upon the cut-off. Now, in the plaintiff's engine, as compared with these engines and the French engine, they are all alike in the fact that they have a liberating valve gear, that is, a valve gear in which the parts separate or are detached from one another to effect the closing. They are all alike in the fact that the governor directs the period of closing, by acting upon some instrument which effects the time of closing. They are all alike in the fact that the valves are opened by the engine, and shut by gravity. But the machine specifically described by the plaintiff differs from the defendant's engine, and from the French engine, in the fact that it belongs to that class of liberating valve gear which may be termed the trip cut-off gear, and has an instrument in it which is necessary to effect the trip or disconnection, which in other engines is a matter of necessity; and in consequence of employing a third instrument to effect the trip in disconnection, the engine specifically described by the plaintiff has the governor less impeded or hampered, and it is therefore susceptible of more delicate regulation, if that be necessary; and that point which is the difference of
382 the plaintiff's from all the others is not found in the defendants's machine.

907 Q. On the French engine, point out to the court what it is that you call the stop or yoke.

A. What I call the stop or yoke on the French machine are these two black yokes, which embrace the rotating cam, and which, when acted upon by the engine, as directed by the governor, shifts the position of the cam so as to vary the period of cut off.

908 Q. In regard to patent 759, for "the combination of liberating valve gear with valves which are moved parallel to their seats, and continue their closing motion after their ports are closed, and commence their opening motion before their ports open, substantially as described." Are there any slide valves that do not come within that description that you know of?

A. I never heard of or saw one in a book or a machine that did not pass over the port after the port was closed; because if it did not, it would not be steam-tight.

909 Q. Did you hear the testimony of Mr. Edward Renwick in respect of the plug valve, or the check ring in the bottom of the puppet valve?

A. I did.

910 Q. What is your opinion.

A. My opinion about the puppet valve with the check ring is, that it is a valve which passes beyond its port after the port is closed; and it has, in that respect, the peculiarity of the slide valve; and it also begins to move before the port is opened.

911 Q. Have you seen the patents of Mr. Sickles that are referred to in these exhibits?

A. I have, sir. I find it stated somewhere in this patent that the valve gear, which is a distinct thing from the valve, is applicable to either single, or double, or slide valves, and may be used in combination with the tripping valve gear of Sickles, (patent of 1845.)

912 Q. You saw the pamphlet of Sickles?

A. Yes, sir; many years ago.

913 Q. Are slide valves, puppet valves, and other forms, indiscriminately used in construction, as the judgment of the engineer dictates?

383 A. As the exigency of the case and the judgment of the engineer dictate, people use puppet valves, or slide valves, or piston valves, or Cornish valves.

914 Q. What is a piston valve?

A. The piston valve is a peculiar form of slide valve. [Describes it on model.]

(The court did not think it important to go beyond the puppet valve and slide valve in this case.)

915 Q. What is the proper motion of the working of steam-engines in opening the steam valves?

A. The motion is to open the steam valves just as slow as you possibly can, and at the same time have the full boiler pressure on the piston just after it is off the centres. While the engine is very nearly on its centres, the motion of the piston with reference to the crank is quite slow; so that while the crank is going quite fast the piston is going very slow; but when the piston gets down into the cylinder, it moves as fast as the crank does. As the piston is moving at the least possible rate when on the centres, a very little hole to admit steam will admit it fast enough to fill up the space: but as the piston moves faster, the steam must be admitted faster. If the steam is admitted violently, just when the piston is leaving its centres, you are obliged to take up all the play in all these joints; and not only that, but you have a jar on the parts tending to break them. The object is to get steam on to the engine as easily as you can, and at the same time have the full boiler pressure at the instant at which it is capable of doing any work.

916 Q. In practice, what effect is produced in the steam-engine if the steam valves open too rapidly.

A. You can hear the jar at each revolution as if the whole engine was coming down together when the engine is passing its centres. In order to get rid of that jar they go to work and key up the engine too tight. These continual jars tend to break down the parts of the engine.

917 Q. What is done practically as a general operation on steam-engines?

A. One is to reduce the lead on the steam valve, and to put the lead on the exhaust.

384 918 Q. What does that do?

A. It takes the force off the engine that is driving her in

one direction before coming to the dead centre, shuts up steam in the exhaust cylinder, and makes a cushion of it.

919 Q. Is that attended with loss of power?

A. Practically, not. It is a gain of power practically.

Cross-examined by Mr. Stoughton.

920 x Q. Have you, prior to 1848, seen in operation in this country a good many steam-engines?

A. I had seen a good many engines prior to 1848, but chiefly in steamboats.

921 x Q. You have also seen stationary engines in manufactories?

A. I have not seen, prior to 1848, stationary engines in manufactories; that is, in cotton and wool factories, and those kinds. In fact, all I saw, prior to 1848, in those factories were driven by water.

922 x Q. Had you seen many stationary engines about anywhere for any purpose?

A. I had seen a great many stationary engines in machine shops.

923 x Q. Had you, prior to 1848, seen in practical working on any steam-engines a mode of regulation by the governor, except by attaching it to the throttle valve?

A. I do not think I did, sir. I do not remember having seen it in practical operation prior to that date.

924 x Q. Had you ever seen anywhere, in actual operation, an engine working with any other than that, self-regulating?

A. That is the same question, is it not?

925 x Q. Were either of those modes of regulating, otherwise than by the throttle valve, to which you have called the attention of the court, known to engineers in this country before 1848?

A. I do not know what other engineers knew. I knew of them.

926 x Q. You knew of them from what sources of knowledge?

385 A. From books.

927 x Q. Books accessible to engineers generally?

A. If they had the money I suppose they could have bought them.

928 x Q. Were they in libraries accessible to the public?

A. I suppose they were. I really cannot charge my memory with that.

929 x Q. Do you wish the court to understand that, in your judgment, either of the modes of regulation to which you have called their attention, by applying the governor to the steam valve, was a better mode than applying it to the throttle valve?

A. I wish to state exactly what I did: That, in some instances, where the cut off is short, and the engine is at full load, that the application of the governor to the cut-off valve makes a loss of power, and that its application to the throttle valve would be better.

930 x Q. Do you mean, or have you intended that the court should understand you, that you regarded either of the modes of regulation by means of cutting off at the steam valves, known prior to 1848, as better than the mode of regulation by the throttle valve?

A. In some instances they were better.

931 x Q. And how as to others?

A. In some instances they would be worse; just precisely as with these modes of regulation now by the cut-off; in some instances economy is gained by their use, and in some cases exactly the contrary.

932 x Q. Tell the court in what mill or manufacture, in your judgment, an engine regulated by the throttle valve will regulate better for general work than an engine regulated according to Corliss' invention?

A. In any factory in which the load is such and the power of the engine such that when working at the maximum load the engine is at the best point of cut off. Because in these, cutting off when work is thrown off, this power is reduced below the best point, and steam is lost, which would not be if the cut-off was applied to the throttle valve.

933 x Q. Is there any cotton or other factory where, in your
386 judgment, it would be better to work the machinery, as generally worked, to regulate by the throttle valve than by Corliss' mode?

A. Do you mean known to me by what I have heard? because I can only know by taking cards from engines myself. But in one of the mills described by one of the gentlemen examined, in which he said that, with the whole load on, the engine averaged one-eighth, and dropped below that: in that engine economy would have been gained by taking the governor off the cut-off and applying it to the throttle valve. The regulation would have been just as good, for I have seen regulation by the throttle valve as good as by the cut-off.

934 x Q. And yet you are speaking of a case in which the witness testified he gained one-half the fuel?

A. Yes, sir; but he did not tell how leaky his piston was, or other things, which might have accounted for the whole loss of fuel, and more too.

935 x Q. I understand you to decline naming any mill in which it would be better to use the throttle valve than Corliss'?

A. I say it is impossible for me to know, unless I take the indicator and examine.

936 x Q. You do not know which is best?

A. I do. If you give me the conditions of the engine and mill I will tell you.

937 x Q. Suppose you were called upon to construct an engine for a cotton-mill, as originally run, which would you regard as the best mode of regulation, by the cut-off or the throttle valve?

A. That would depend upon how they told me they carried on their work in the mill. If the work in the mill was pretty nearly uniform, as it is generally in a mill, and portions of the work were only thrown off for a short time, I should put in an engine cutting off at about the best possible point, and regulate by the throttle valve. But if the maximum load was the exception and not the rule, and if I did not want to build too big an engine, and be working at a loss

of power when doing the usual load, then I would attach the governor to the cut-off.

938 x Q. You have spoken of the Allen patent as a mode of
387 connecting the governor with the expansion valve. Did you ever see an engine constructed in accordance with that patent in use?

A. I never have, sir.

939 x Q. Did you intend to convey the impression to the court, when you stated that you had seen the old plug-tree arrangement in use on working engines, that you had seen them in use combined with the governor?

A. No, sir.

940 x Q. Then, you never saw the old plug-tree arrangement used on an engine combined with the governor?

A. No, sir.

941 x Q. Do you know that it has been stated in the books that that plan of arrangement has long since been discontinued?

A. No, sir. It may be stated in the books, but that is not conclusive. A book has been published in which the author proves, to his own satisfaction, that there is loss in using steam expansively, but that does not convince me he is right. That is a Mr. Isherwood.

942 x Q. Be kind enough to point out, in the French model, the sleeve of the governor?

A. There is no distinct part which can be called the sleeve of the governor.

943 x Q. Or the slide of the governor?

A. There is nothing that can be called the slide of the governor.

944 x Q. Is there anything which moves up and down connected with the governor, as the balls move?

A. There is. It is a sleeve connecting these two bevel wheels.

945 x Q. Is not *that* the sleeve or slide of the governor, as there exhibited?

A. It is, sir; you may call it so.

946 x Q. *That* you call the sleeve or slide of the governor?

A. I say it may be called so. It is not usually called so.

947 x Q. Is there anything else you may call the sleeve or slide of the governor on that?

A. No, sir.

388 948 x Q. Tell the court what you call, in this French model, the yoke.

A. *This* little black thing here. [pointing.]

949 x Q. Now, is that moved up and down when the sleeve of the governor is moved up and down, or is it moved at all as the sleeve of the governor moves?

A. It is very often.

950 x Q. As I move the sleeve up and down is there any motion given to that yoke?

A. Very often there is.

951 x Q. As I move it up and down now?

A. No, sir; not when the engine is not in motion.

952 x Q. Is there any motion communicated to that yoke by the upward or downward motion of the sleeve, unless *this* cog-wheel works into *that*, and by the power of the engine works that along?

A. Certainly not, sir. That is, as I explained, a distinctive peculiarity of the mill-governor.

953 x Q. Now, sir, do you see any sleeve or slide connected with the plaintiff's governor on the blackboard?

A. Yes, sir.

954 x Q. As the balls move up and down what moves with the sleeve?

A. The active instrument which effects the disengagement—the helical cam.

955 x Q. As I understand you, the slide of the governor is connected directly with these balls. As the balls move up and down they move up and down that helical cam?

A. No doubt.

956 x Q. And the position which the cam takes is due to the rise and fall of the balls?

A. Yes, sir.

957 x Q. As that takes one position or another it determines the period of liberation of the valve?

A. Yes, sir.

958 x Q. And consequently determines the extent of cut off?

A. Certainly it will.

959 x Q. We now go to the valve gear of the defendant's and the plaintiff's machine. I understand you to say that the valve
389 gear of the defendant's always cuts off before it reaches the end of the stroke, whether the gauge bar was applied to the tappets or not?

A. The parts always separate.

960 x Q. And hence the cut off?

A. It may, if it takes place sufficiently soon.

961 x Q. The parts will always separate, whether the gauge bar is applied to move the tappet up and down or not?

A. Certainly.

962 x Q. Have you seen the defendant's machine in operation?

A. Yes, sir.

963 x Q. Did you ever see it when at work disengage, except when regulated by the motion up and down of the gauge bar?

A. I never did, because it was always set to regulate by means of the governor.

964 x Q. Do you not understand that the purpose of the defendant's machine is to be used with the gauge bar, connected with the governor, for the purposes of regulation?

A. When it is used for purposes of regulation.

965 x Q. Did you ever see it run at any time except when regulated?

A. No, sir.

966 x Q. You have seen the plaintiff's engine at work?

A. I have.

967 x Q. Did you ever see it in operation, except when it cut off by means of the regulator and the stop on gauge bar?

A. I have, sir. I have seen it in regular working operation, cutting off at a given point without the governor determining the point of cut off.

968 x Q. With the governor removed?

A. Yes, sir. In one, a steamboat engine he put up, that did not want any governor, and in another where it did not regulate well, and they took the governor off.

969. Have you ever seen his engines working, having the governor regulating and cutting off the steam?

A. I have seen several of them.

970 x Q. Did you ever see one on which the governor was used at the time you saw it that did not cut off by means of the stop connected with the governor?

390 A. I saw one on which the governor was pinned up, and which cut off when the governor had no effect upon it; but in all other cases the governor affected the position of the stop.

971 x Q. Then, in the defendant's and plaintiff's machine, the purpose is to use the gauge bar or stop for the purpose of regulation?

A. That is the purpose when they want regulation.

972 x Q. Where was the machine in which the governor had been taken off?

A. The machine in which the governor was pinned up was in Providence. I forget exactly where.

973 x Q. Cannot you give the place you saw it?

A. No, sir; I think it was somewhere close beyond the court-house in Providence. I noticed the engine did not vary its cut-off at all. The man told me the governor was pinned up, and I saw it was.

974 x Q. Was it not a little engine that drove the blowers for the court-house?

A. It may have been.

975 x Q. Was any regulation required there?

A. If no regulation was required, they were very green to buy a Corliss engine and pay a large price for it.

976 x Q. Is that your only answer?

A. That is my only answer, because I do not know what the engine had to do.

977 x Q. Could you not have said that without speaking of the greenness of the customer?

A. No, sir; not very well. The other engine I saw was the largest I ever saw of Mr. Corliss'. The cut-off could be regulated by the hand of the engineer. No governor was put upon it.

978 x Q. When did you first see slide valves combined and working with detachable valve gear in actual practical use?

A. I do not know, sir.

979 x Q. State as near as you can recollect.

A. I cannot, sir; for I may have seen it without knowing it.

980 x Q. Well, when you knew it. You are here to testify to what you know.

391 A. I do not want any directions on that head. I could not have known without taking off the valve chest and seeing what kind of valve was in it.

981 x Q. When did you first see a governor working with detachable slide valves?

A. To know it of my own knowledge it was one of Green's engines. That was the first where I took the bonnet off, and saw it had a detachable slide valve.

Redirect.

982 Q. This steamboat engine you spoke of—where was that?

A. That was an engine put into the *Enoch Dean.* It had the Corliss valve gear.

983 Q. How did that operate?

A. I cannot speak except from report.

984 Q. In respect to the engine you saw at Providence running a blower to ventilate the building—is a regulator a desirable thing on such an engine?

A. Yes; it is desirable.

CHARLES W. COPELAND sworn.

Examined by Mr. Dickerson:

985 Q. What is your present profession?

A. I am an engineer by profession. I am engaged mainly in designing and superintending the building of engines for various works. I occupy the position of supervising inspector for the second district, under the U. S. government.

986 Q. How long have you been engaged and familiar with the construction and operation of steam-engines?

A. Some 25 or 26 years, or along there.

987 Q. Has that been your business all the time?

A. Ever since I was 14 years of age. I first went to the business in the city of Hartford.

988 Q. Have you been connected, as superintendent or otherwise, with a steam-engine manufacturing establishment?

392 A. I have.

989 Q. Where?

A. I was first superintendent of my father's establishment in this city, next of the West Point foundry at New York, and afterwards at the Allaire Works, New York.

990 Q. What was the extent of those last-named establishments?

A. They were as largely engaged in this kind of business as any establishment of the day.

991 Q. What kind of engines have you been engaged in building and superintending?

A. Almost every variety of engines—some to a limited extent, and some very largely.

992 Q. You have been an engineer of steamboat lines, have you not?

A. I have.

993 Q. Employed by the government to build engines?

A. I have, sir.

994 Q. For their government steamships?

A. I have, sir.

995 Q. Have you been familiar with the extent and progress of the use of steam-engines for manufacturing purposes, and the progress of improvement in steam-engines for a considerable period?

A. I have, sir.

996 Q. How?

A. I made it my study since I first went to the business. I try to keep as well posted as I can.

997 Q. Fifteen years ago what was the general state of the art of engine building for manufacturing purposes?

A. The style of engine then in most common use was the ordinary slide-vale engine, high pressure, with the governor applied to the throttle valve.

998. Q. Were there a great number of manufacturing establishments then driven by steam?

A. The proportion driven by steam was then very much less than now. I suppose the number of manufactories driven by steam now is many fold greater than before. There were a great many kinds then limited to water-power now driven by steam.

393 999 Q. What attention was then given to the economy of fuel?

A. It was scarcely thought of. A steam-engine was a steam-engine as long as it worked.

1000 Q. I wish to call attention to patent No 763 of Mr. Corliss. Have you examined that patent and read it?

A. I have read it, sir.

1001 Q. What is the mode of operation described in that patent?

[The court thought it hardly necessary to go into that matter again, as it had been sufficiently explained.]

1002 Q. Look at the description in the patent of the regulator combination, line 15: "The former is an instrument which, when set in motion, changes the relative position of some of its parts, as changes occur in its velocity, and by virtue of such changes is capable of communicating motion to other mechanism." What is that a description of?

A. It is a description of several forms of regulator or governors as applied to steam-engines.

1003 Q. What is the fact about the number of forms of governor that existed at the time of this patent in 1848?

A. There was the ordinary fly-ball governor, the mill-governor, the hydraulic governor, the pneumatic governor, the air-vane governor, one called Seamen's governor, and perhaps some others.

1004 Q. Under these different general terms how many forms or modifications or variations of governor were there in existence?

A. Of the fly-ball governor, including the mill-governor as of that class, there were perhaps four different arrangements of that, or five. Of the hydraulic governor I cannot say how many, the details have

been changed variously. Of the pneumatic governor there were, I believe, two distinct forms; and of the vane governor, two or three.

1005 Q. Do they all come within this description?

A. I should say so, sir.

1006 Q. How long have you been acquainted with the form of governor known as the mill-governor?

394 A. Ever since I was old enough to read a word on mechanics to understand it.

1007 Q. Are these machines in common use?

A. Yes, sir.

1008 Q. Is there any difficulty about their operation?

A. Not that I am aware of; nothing more than to get them properly proportioned.

1009 Q. Look at the machine before you—the French machine. Have you seen the drawings of that machine in the books referred to here?

A. I have.

1010 Q. When did you first see the 5th vol. of the French work in evidence?

A. I took this work in numbers—it generally came in single numbers—and I find on the letter-press of vol. 5 an endorsement in my own handwriting, July 12, 1847, which is undoubtedly within two or three days of the time I received it.

1011 Q. Looking at that engine, and supposing it to be perfected according to the drawings contained in that publication, is that, in your opinion, a practically operating engine, or otherwise, in regard to capacity to operate?

A. Certainly; it is an operating machine.

1012 Q. Any difficulty about that working?

A. No, sir.

1013 Q. Have you examined it carefully?

A. I have repeatedly.

1014 Q. Now the other machines that have been referred to. Take that Tredgold machine for illustration. Will you answer the same question in regard to that? Is that machine, assuming it to be completed in respect to the parts in the drawing, a practically operating machine?

A. It is.

1015 Q. How would that operate in regulating the steam-engine? Would it be a good regulating machine, or otherwise?

A. It would be a very good regulating machine. The only difficulty in regard to it is, that the governor would be hampered during the time the valves opened—not so free as in the mill-governor.

395 1016 Q. The governor would not work as well as the mill-governor?

A. No, sir.

1017 Q. In respect to regulation by applying the governor to the cut-off, is there any difference between the effect of regulation,

whether the governor is applied to the cut-off valve outside of the distributing valves, or applied to the distributing valves themselves?

A. Confining the question simply to regulation, there is no difference.

1018 Q. One would regulate as well as the other?

A. Yes, sir.

1019 Q. In respect to economy of fuel, which would be most economical?

A. The one where it was attached or connected to the distribution valve; for the reason that the steam cuts off closer to the cylinder.

1020 Q. Is that result depending on the fact of its being the regulating cut-off, or the fact of its position on the engine?

A. To the fact of its position.

1021 Q. Regulation has nothing to do with the difference?

A. No, sir.

1022 Q. There are two classes here of liberating valve gear; one of which is a detachable valve gear, commonly called the Sickles cut-off. To which of these classes does the machine of Green belong?

A. It belongs to the class termed the cam cut-off; is similar in its operation to that.

1023 Q. Will you state to the court what it is of that class that consists of the distinguishing peculiarity of cam cut off?

A. Because that in both the defendant's machine, the French machine, and others of this class, liberation is effected by the movement of the parts themselves. There is no independent instrument interposed to produce the result. In Sickles, and others of that class, another instrument is interposed to produce that result.

1024 Q. The introduction of that instrument is what constitutes a new class?

396 A. Yes, sir.

1025 Q. Now, sir, so far as the liberation is concerned, in respect to the effect of that distinction upon the capacity of the governor to regulate the engine, as to its sensitiveness, what is the difference between the two in that regard?

A. The same class of governor, the fly-ball governor being applied in each case—in the French machine and in the Tredgold and defendant's—they are all hampered during the time the valve is being opened or open, while the parts are in contact for opening the valve. In the plaintiff's machine, and others of that class, it is only hampered at the instant the cam or stop is brought in contact to produce the disconnection or liberation.

1026 Q. The time in the Sickles cut-off?

A. Is a constant quantity. The time in all the others has relation to the point of cut off; the longer the cut-off the longer it is hampered, and the shorter the cut-off the less it is hampered.

1027 Q. The sensitiveness of the governor is more or less affected by the work the engine is doing in the cam cut offs?

A. Certainly.

1028 Q. In the other case (trip cut-offs) it is a constant quantity, depending on the form of the cam or stop?

A. Yes.

1029 Q. Now, looking at the patent No. 780, I call attention particularly to the nineteenth and twentieth lines, and also to line fifty-seven, what machine is described there?

A. It is a hook on what is termed the spring bar, in combination with the arm of the valve or rocking lever, as it is called.

1030 Q. Considering these two elements together for the purpose of opening the valve, what is that device?

A. Well, considering the two by themselves, as described here, it is nothing more than the old eccentric hook and rocking arm—the same that has been used ever since I can remember. I have seen the eccentric hook in different forms—that is, I have seen it made to allow what is called lost motion between the hook and the pin—the shoulder not fitted closely to the pin, but being separated five
397 or six or eight inches, so that there is loss of motion on this rod.

1031 Q. That was for the purpose of cut off?

A. Yes.

1032 Q. Explain that.

A. The two shoulders, instead of being separated by the distance that would take up the pin, were separated distances of five or six inches, so that the distance between the two shoulders is five or six inches greater than the size of the end of the pin upon which it is hooked; the result was that amount of lost motion—the object being to produce the cut-off.

1033 Q. How does it operate to produce the cut off?

A. The motion being lost here, the valve returning by gravity would return to its seat before it hooked on again; therefore, the valve would be closed before the regular movement to bring it to its seat, and remain closed until the shoulder caught it again.

1034 Q. I call attention to the original patent of 1851, Exhibit L, of which this is a reissue, page 20, line 40: "Hence, as long as these hooks continue engaged with the toes of the rock shaft arms, the steam valves will be opened and closed with a regular movement in the same manner as the exhaust valves." Is that a true description of the opening of that thing and this?

A. It is a true description of that and this in any ordinary engine.

1035 Q. Does it differ from this machine, the old hook, in that particular?

A. Not in that particular.

1036 Q. When you put in the other part and make a cut-off of it it becomes another question?

A. Yes.

1037 Q. Now, keeping the same patent in your hand, is the device, considered as a device, the same thing, or substantially the same as the sliding bar with its spring tappets, and tappet or plug-tree on Green's engine?

A. I should say not.

1038 Q. Now, in regard to the other combination that is spoken of there—the second combination in patent 780—what is that
398 made of? I refer to line 60: "In combination with the shoulders on the spring bars that operate the rocking levers, substantially as described, the employment of the gauge bars, or any equivalent therefor, to regulate the periods of closing the valves, whether the said gauge bars be regulated by a governor, or by other means as set forth." Is the combination there described substantially the same or different from that on the Green engine?

A. Substantially different.

1039 Q. The gauge bars that are spoken of there, in this patent, are the stops on the machine?

A. The gauge bar in plaintiff's machine operates as a fulcrum over which the spring bar throws off the pin.

1040 Q. Do they perform the same office of gauge bar in the other machine?

A. Not at all—not in that manner.

1041 Q. I do not speak of the general result, but of the manner of operating the rocking lever.

A. He speaks here of the gauge bar, or any equivalent therefor. I suppose the word "equivalent" is used in the sense of an instrument performing substantially the same duty in substantially the same way.

1042 Q. You have in your possession a pamphlet of Sickles. How long have you had it?

A. I have had it since about the date it was issued. I cannot say within a few days. The date upon it is 1844.

1043 Q. The statement there published is that this cut-off is applicable to slide valves and puppet valves. Is it, in your opinion, an invention to put Sickles' cut-off to the slide valve?

A. I should say not. This pamphlet intimates how it may be done. It is a very simple matter.

1044 Q. Is it a question of invention, or a question of the judgment of the engineers merely to substitute one of the various kinds of valve for another?

A. It is merely a question of arrangement of the device by which one is put for the other.

1045 Q. When an order is presented to you to build an engine, do you make the arrangement always? You have to select the valves?

399 A. I have to select the valves. Sometimes I use one kind of valves, sometimes another.

1046 Q. Those were all well-known forms of valves known at that time?

A. Yes, sir.

1047 Q. You have heard the testimony of a gentleman named *Stearns*, and of another, as to saving fuel; you heard the conditions they gave of their engine. Is there any economy of fuel in the cases given by using the governor upon the cut-off rather than using it by the throttle valve, and setting it at the point of maximum load?

A. Not by the conditions given in their testimony.

1048 Q. You have calculated about that?

A. Yes, sir.

1049 Q. The thing is capable of demonstration?

A. Yes, sir, setting aside leaks.

1050 Q. Assuming the engine equally perfect in both cases, and equally defective in both cases?

A. Yes, sir.

Cross-examined.

1051 x Q. You have stated that fifteen years ago the proportion of steam-engines to those driven by water was not large?

A. If I recollect what I stated, it was that there were less steam-engines in proportion to the number driven by water than now.

1052 x Q. I understood you to state that you gave attention very early to the construction of engines for manufacturing purposes?

A. Yes, sir.

1053 x Q. Did you, prior to 1848, make engines for that purpose or cause them to be made?

A. Yes, sir.

1054 x Q. Many of them?

A. Yes, sir.

1055 x Q. Did you ever, prior to that time, construct a steam-engine combining the slide valve with detachable valve gear?

A. No, sir.

400 1056 x Q. I suppose that regulation was of as much consequence fifteen years ago as now in engines for manufacturies?

A. Yes, sir.

1057 x Q. Although fuel was of less consequence?

A. Yes sir.

1058 x Q. Prior to 1848 did you ever construct an engine, or see one in operation in this country, regulated by means of a governor attached to any other than the throttle valve?

A. If by the term "throttle valve" you mean any valve interposed in the steam-pipe—if you mean any valve in that position to throttle the steam, my answer will be no.

1059 x Q. You never have?

A. Not that I now recollect.

1060 x Q. Did you ever see a machine in operation having the arrangement for regulation which you see in the French model?

A. Not in that form, sir. I have seen the same arrangement embodied, but not in that form.

1061 x Q. You have seen an engine working the valve by a cam, and the cut-off regulated by the governor?

A. Yes, sir; by moving the position of the cam, as in this case.

1062 x Q. But there the mill regulation was interposed connected with the fly-ball?

A. The mill regulation was not.

1063 x Q. Where did you see that engine?

A. In New York.

1064 x Q. At whose establishment?

A. At the Phœnix foundry.

1065 x Q. The slide of the governor was in that engine attached, or rather the change of the cam was to be operated by the slide of the governor?

A. Yes, sir; and the cam actuated the slide valves.

1066 x Q. When did you first see that?

A. I cannot state exactly; but I suppose five or six years ago.

1067 x Q. I understand you to say that this mode of screw-
401 ing the cam along by engaging cog-wheels moving on the slide of the regulator was entirely dispensed with?

A. Yes, sir.

1068 x Q. And the slide of the regulator, moving as the balls moved up and down, determined the position the cam was to take by a direct connection between *that* and *this?*

A. Yes, sir.

1069 x Q. (By Mr. Curtis.) Was that cam which opened the valve in this engine the same cam which let it down?

A. It was the same cam which let it down. It was a slide valve; but I am not positive whether the slide valve was a mere cut-off, or whether it was a distributing valve.

1070 x Q. Taking that point to be doubtful, I want to inquire whether the cam that opened the valve was the same cam that the governor was connected with to let it down?

A. That is my recollection.

1071 x Q. Are you positive about that?

A. I am not positive. I speak to the best of my recollection. I suppose it is three years since I saw that thing.

1072 x Q. In Hogg & Delamater's foundry that was?

A. Yes, sir.

1073 x Q. (By Mr. Stoughton.) You stated that the combination of the slide valve or puppet valve would be left to the judgment of the engineer?

A. Yes, the modification.

1074 x Q. Whether you would use one kind of valve or the other?

A. I mean as to the manner in which the governor was connected with the valve.

1075 x Q. I now go to the union of the valve with the gear. I understand you to say that whether you would unite one kind of valve to the gear or another would be left to the discretion of the engineer, and would not be a matter of invention?

A. It is generally so in the construction of engines.

1076 x Q. I understand you to say it did not require invention to unite the slide valve with the valve gear by Corliss, puppet valves having been united before?

402 A. I did, sir; and with the information contained in this pamphlet issued by Sickles. The mode of connection being shown in the puppet valve it could hardly require invention to adapt the same mode to slide valves.

1077 x Q. Without that pamphlet, would it require invention?

A. With detachable valve gear before me, I think it would not require invention.

1078 Q. But you never did it?

A. No, I never did it.

Redirect.

1079 Q. Suppose you were called upon to regulate the engine, and had to do very accurate turning, and had a choice between the fly-ball and mill-governor and only that, which would you choose?

A. The mill-governor would make the most perfect regulation undoubtedly.

ZACHARIAH ALLEN sworn.

Examined by Mr. Dickerson:

1080 Q. What is your present employment; and what has it been for many years past?

A. I have been a manufacturer for many years, from 1822.

1081 Q. What description?

A. Woolen manufactures and subsequently in cotton.

1082 Q. Have you ever been engaged in the manufacture of steam-engines at all, as a business?

A. No, sir; I never have.

1083 Q. Have you given a good deal of attention to the subject of machinery and mechanical operations?

A. Yes, sir; it has been the favorite pursuit of my life.

1084 Q. Have you ever published a treatise on mechanics?

A. I have.

1085 Q. Among other branches, have you turned attention to the properties of steam and the application of the steam-engine?

A. I have, sir.

403 1086 Q Did you received letters patent in 1834 for an improvement in the steam-engine?

A. I have. [Produces them.]

1087 Q. Are these the original letters patent?

A. Yes, sir.

1088 Q. That patent bears date in 1834, I believe. The specification relates to an improvement by combining the regulator with the cut-off. I ask whether, at any time, after obtaining letters patent, or before, you embodied your improvement in any working machine?

A. It was, in the first place, embodied in a model corresponding with the drawings of the patent which was issued. Afterwards it was applied to a small steam-engine in a manufactory in the city of Providence where it remained in operation some time.

1089 Q. After that it was applied to a machine—a working machine?

A. To a working steam-engine, in a steam-engine manufactory, in the city of Providence.

1090 Q. Whose establishment was it?

A. It was called the Wadsworth Steam-Engine Company.

1091 Q. What became of that establishment?

A. The owners failed. It was used subsequently for a bleaching and printing concern.

1092 Q. Did they continue business long after the introduction of the improvement you patented?

A. A very short time, I believe.

1093 Q. While they continued in operation, was the steam-engine that embodied this improvement in operation?

A. It was. I do not know that it was during the whole time, but I know it was during some months. My memory is somewhat imperfect, it is so many years ago.

1094 Q. Your own personal pursuits were entirely of a different character from building steam-engines?

A. They were, sir.

1095 Q. How, in this specific machine, was the regulator attached to the instrument which determined the period of cut off? Can you show so that we can understand it?

A. [Explaining.] There was a vertical fork placed on that
404 lever, which, by the movement of that fork, would sway the lever horizontally upon the cam, which had a wedge shape. By the movement of the lever horizontally in one direction it would approximate to one end of the cam and would allow more steam to pass upon the piston; when the end of the lever was moved over the smaller part of the cam it let the steam flash upon the piston for an instant, and cut off.

1096 Q. If the governor balls were changed, and diverged from each other, would there, or not, be any corresponding change in the position of the lever as it rode on the cam?

A. The effect of the rise and fall of the balls was to sway this lever back and forth. As they rose and fell, this lever would sway back and forth.

1097 Q. Suppose the governor balls were as near together as they could get, in working the machine, where would be the position of the tail of the lever which was in connection with the cam?

A. That would throw it up to the large end of the wedge-shaped cam.

1098 Q. Then, if the governor balls were extended far apart, where would be the position of the lever?

A. It would approximate it to the short end, to cut off more speedily—to prevent the admission of steam acting so long. That was the design of the plan.

1099 Q. The mode of operation was somewhat different from what was represented in these drawings?

A. It was practically put in operation upon a different plan—a more simple one than was laid down in the drawings.

1100 Q. Be so good as to explain in the drawing how you contemplated to put it in operation, in order to distinguish it from the mode in which it was put in operation.

A. The original plan was to apply a conical ball pendulum, to vibrate a lever, or rather to work a screw, passing round a wheel or pulley on a shaft, having a screw cut thereon, and upon which shaft there was a lever, having a screw cut therein, by returning of which shaft this lever would be made to traverse back and forth, according to the direction the pulley was turned by the movement of the driving position of the wheel or pulley attached to the reg-
405 ulator. As the balls rose it engaged the wheel on one side, and as they dropped, on the other, reversing the movement; and, according to the reversal of this movement, the wheel on this shaft would be worked back and forth, and with that movement back and forth of the pulley, the screw attached to the pulley would work back and forth, and with it thrust back and forth the lever which was fixed thereon as on a pivot.

1101 Q. (By Mr. Curtis.) What did the lever do?

A. One end of the lever rose and fell upon the cam. The other end was attached to work the valve, to open and shut it. The machinist, in applying this, simplified the plan I devised, by simply connecting the rise and fall of the balls with the horizontal movement of the levers, leaving the lever between two pins, having one end fast, and the other carrying a little cam on the main shaft.

1102 Q. You dispensed with the screw contrivance exhibited in the drawing, but made a direct connection between the governor and the lever?

A. Yes, sir.

1103 Q. (By Mr. Thurston.) Has the original patent which you hold been in the possession of Mr. Corliss?

A. I cannot say it was in Mr. Corliss' possession. Mr. Nightingale called and took it.

1104 Q. Is Mr. Nightingale a partner of Mr. Corliss?

A. Yes, sir.

Cross-examined.

1105 x Q. When did Mr. Corliss' partner borrow your patent?

A. Probably two or three years ago—a short time ago.

1106 x Q. What was the size of the engine put up on your plan?

A. I cannot recollect distinctly, but I presume a small one—20 or 30 horse power.

1107 x Q. You think it was operated a few months?

A. Yes, sir.

1108 x Q. Do you know what then became of it?

A. I do not know.

1109 x Q. Did you ever construct another?

406 A. I never did but one. There was a cam put on the main shaft of a steamboat in Providence. That was used for the saving of steam, but not attached to the regulator. That was in use for a considerable time.

1110 x Q. This regulator valve you have mentioned, where was it placed in the steam pipe which led from the boiler to the valve chest?

A. As near as possible with the puppet valve.

1111 x Q. In the same steam pipe in which the throttle valve was ordinarily placed, but nearer to the steam valve?

A. Yes, sir. I believe somewhat similar to what Mr. Ericcson is now using.

1112 x Q. You used steam valves in addition to it?

A. They were thrown open to allow steam at full stroke. The steam valve was allowed to have full expansion of steam, and to be governed by the cut-off, so as not to be throttled.

1113 x Q. You used one fly valve for both steam valves?

A. Yes, sir.

1114 x Q. And distributed at each end of the cylinder by that valve?

A. Yes, sir.

1115 x Q. Could you have got along without using steam valves in that plan?

A. Yes, sir.

1116 x Q. Could you have thrown them away and still used your engine?

A. It was used without it.

1117 x Q. Do you mean to say your steam valves were always left open, and never at any time closed?

A. They were opened and closed, but they did not regulate the admission of steam. They gave full expansion of steam to the cylinder, as if not there.

1118 x Q. All the expansion of the steam was had after it passed your fly valve?

A. Yes, sir. They did not detach them, but left them on the engine.

1119 x Q. They opened and closed, letting the steam in at full stroke?

A. Yes, sir.

407 1120 x Q. But you could not do without them on that engine?

A. No, sir.

1121 x Q. As I understand the description, you say the difference between that arrangement and the one reduced to practice on the machine was you threw away the intermediate screw, by means of which you screwed the valve toe on the cam?

A. Yes, sir.

1122 x Q. And attempted to use, by means of the fork, your governor, connected with the fork, so as to pull the toe of the valve along as it rode on the cam?

A. Yes, sir. It caused it to vibrate horizontally by the surface of the cam on the main shaft.

1123 x Q. That fork, as the fly-ball governor changed the position of its arms, would be pulled along, so as to drag the tail of the valve lever along the surface of the cam that opened the valve?

A. Yes, sir.

Redirect.

1124 Q. How did the machine work and regulate?

A. It regulated perfectly. I counted it, and found that it regulated as perfectly as the old way had done with the throttle valve.

1125 Q. What was the engine used for?
A. It was a steam-engine manufactory; but they never built but wo or three engines. They had but small capital, and failed.
1126 Q. Did it drive the load in that shop?
A. All that was working in the shop it drove.
1127 Q. How was it in economy?
A. I do not remember about the economy. I was taken up with ıe mechanical arrangement of it. I have no doubt of the result of ıe economy, theoretically.
1128 Q. What year did you say you put it in operation?
A. I could not say distinctly the year; but it was very soon after the patent was obtained.

)8 WILLIAM SPINK sworn.

Examined by Mr. Thurston:

1129 Q. What is the nature of your occupation?
A. Taking care of a cotton-mill.
1130 Q. As an engineer?
A. As superintendent.
1131 Q. Have you ever been otherwise engaged?
A. I have, sir.
1132 Q. In what employment?
A. As engineer.
1133 Q. For whom?
A. Dexter & Bros., Valley Mills, R. I.
1134 Q. How recently did you leave their employment?
A. I am in their employment now, as superintendent.
1135 Q. How recently were you employed by them in any other ıpacity than superintendent?
A. About three years, as engineer.
1136 Q. While you were engineer, what kind of engine did you ıve there?
A. They had Mr. Corliss' when I first went there, and then we had ıe of Mr. Green's.
1137 Q. In the place of it?
A. Yes, sir.
1138 Q. The engine of Mr. Corliss, was it one that regulated by eans of the governor, in connection with any part of the gear?
A. Yes, sir.
1139 Q. Was it, or not, one of his improved engines?
A. It was, sir.
1140 Q. The engine that Mr. Green put on after, was it similar to ıy of the models on the bench?
A. It was, sir (the defendant's.)
1141 Q. After the introduction of the new engine by Mr. Green, hat were the comparative results between the two; what gain, if ıy, was made by one over the other in respect to the consumption fuel?
A. About 40 per cent.
1142 Q. In favor of which engine?

A. Mr. Green's.

409 1143 Q. How did you ascertain it?

A. By weighing the coal.

1144 Q. Did you weigh the coal which you consumed in the Corliss engine?

A. I did.

1145 Q. Regularly?

A. Not regularly; once in about four or five weeks; sometimes two weeks and sometimes a week; and then omit it a spell.

1146 Q. From time to time you would weigh the amount of coal used?

A. Yes, sir.

1147 Q. How with Mr. Green's engine in that respect?

A. We weighed the coal before.

1148 Q. And from the comparison you were enabled to make, do you say there was that saving?

A. Yes, sir.

1149 Q. Was there any change made in the boilers when the new engine was introduced?

A. No, sir.

Cross-examined.

1150 x Q. When did Dexter & Bro. procure the engine which you call Corliss' engine, and which was discarded for Green's?

A. They bought it of Fletcher & Bro.; I cannot state particularly when; I think a little over four years ago.

1151 x Q. Perhaps you can fix the time in your memory; you recollect the commencement of a suit by Mr. Corliss against Dexter & Bro. which had been pending a great while?

A. I do, sir.

1152 x Q. This engine was bought of Fletcher & Co. since that suit was commenced by Corliss against Dexter?

A. I cannot say, sir.

1153 x Q. What is your best recollection about it?

A. My best recollection is, that it was bought before.

1154 x Q. How long did you use the engine that you bought of Fletcher & Bro.?

A. I ran it for Dexter & Bro. over two years.

410 1155 x Q. You were running it while the suit was pending by Corliss against Dexter & Bro.?

A. I cannot say, sir.

1156 x Q. While running that, they were using a Green engine also?

A. That I cannot say.

1157 x Q. Were they not using two steam-engines when you were running that for Dexter & Bro.? Had they not another in another mill?

A. They had one prior to that. I do not know that I ever saw it.

1158 x Q. You heard there was a suit pending for using that engine in the other mill?

A. Not prior to the time the new one was put into our mill. I was called on in the suit, in the first trial at Newport, I think.

1159 x Q. Give the size of the old engine they bought of Fletcher & Bro.

A. 30-horse power; 10-inch cylinder; 3 feet stroke.

1160 x Q. What was the size of the engine put in by Green?

A. 12-inch cylinder; 3 feet stroke, or $3\frac{1}{2}$ feet.

1161 x Q. Do you know at what point of cut off you used the respective engines?

A. The old one usually ran at about $\frac{3}{8}$ths; the new one cut off at about $\frac{1}{4}$.

1162 x Q. Was the engine they bought of Fletcher & Bro. one made by Corliss, or that had his system of regulation attached to it?

A. I cannot say. I never saw the machine until I went to work. Mr. Corliss' mode of regulation was on it.

Mr. Thurston offered in evidence the original letters patent granted to Noble T. Green in March, 1845. Also, upon the question of the air-cushion and liberating valve gear, an argument by Mr. Corliss in opposition to the Sickles patent extension.

Counsel was directed to draw attention to the particular passage he intended to use.

Adjourned to half past 3 o'clock.

411 AFTERNOON SESSION.

SEPTEMBER 25th, 1860.

The court reassembled at half past 3.

ERASMUS D. LEAVITT, jr., sworn.

Examined by Mr. Thurston:

1163 Q. You are a draftsman?

A. I am.

1164 Q. In the employment of Mr. Corliss?

A. Yes, sir.

1165 Q. Have you examined a great many engines in operation?

A. I have, sir.

1166 Q. That were being constructed when you were in the concern?

A. Yes, sir.

1167 Q. Is there anything that they use, in addition to the fly-ball governor, to regulate those engines? and if so, describe it.

A. In the engines which I have seen, to which a regulator was attached, there was a small cylinder, called a dash-pot, in which there was a piston, fitted loosely, and filled with water. This piston is connected with the governor, and the purpose, as I understand, was to prevent sudden fluctuation.

1168 Q. How connected with the governor?

A. Directly with the rod attached to the piston, in this water piston.

1169 Q. What is the effect of that?

A. To prevent sudden fluctuations of the governor.

1170 Q. Did you ever see any that would regulate without it?
A. I never saw an engine running without it.
1171 Q. You are familiar with the Green engine, are you not?
A. I am.
412 1172 Q. Is anything put on that machine?
A. No, sir; except the common fly-ball governor.
[Mr. Curtis objected as immaterial. Objection sustained.]

Cross-examined.

1173 x Q. What you mean, when you say there is a little pot of water to assist in regulation, is this—that the extension, so to speak, of the sleeve or slide of the governor, underneath the governor, runs into a pot of water, and works up and down in it?
A. Yes, sir, substantially; the sleeve is attached to the piston.
1174 x Q. A prolongation of the sleeve of the governor runs into a cup of water, and moves up and down in that water?
A. Yes, sir.
1175 x Q. [By Mr. Dickerson.] Do you mean to say that a piston and cup are the same thing?
A. No.
1176 x Q. What is it attached to?
A. To a piston inside the cup.
1177 x Q. That moved inside a cup filled with water?
A. Yes, sir.
1178 x Q. What is the effect of it?
A. To prevent a sudden movement or change of the balls of the governor.
1179 x Q. It makes the governor a slow governor?
A. Yes, sir.
1180 x Q. [By Mr. Stoughton.] Do you mean to assent to that?
A. I mean it makes it possible for the governor to work slowly.
1181 x Q. You think to operate and bring them up more slowly would prevent tremulous movement?
A. Yes, sir.

HENRY B. RENWICK recalled.

1182 Q. In respect to air and water dash-pots, I wish to
413 recall to your mind some experiments made with the air and water dash-pots some years ago, when the controversy about Sickles' cut-off was involved. Tell the court the operation of this thing with air and water—what you did.
A. There was a Corliss beam engine running at the corner of 22d street and 2d avenue, in a house where they let out power. The chief business was rolling copper or rolling brass. I saw applied to that engine the Sickles form of dash-pot, working upon air, to regulate the fall of the slide valve and the liberating valve gear of that engine. I saw it working for some length of time. I saw the Corliss form of dash-pot, such as is described in the patent, set into a tub of

water, so that the water entered into a small hole in the side of the dash-pot instead of air, which worked the other valve of the engine. The Corliss dash-pot, in water, worked certainly quite as well, and I think better than the other. The Sickles dash-pot worked a little better on water than on air; but both were practically sufficient, either on air or water. When I say working better, I mean they were easier of adjustment in the proper position. After the adjustment was made I did not see any difference.

1183 Q. These are kept running there?

A. I think I saw them at two different times?

1184 Q. Will you refer to the use of an air dash-pot to arrest the fall of the valves?

A. There is an air-cushion. The terms of the patent of Mr. Corliss would apply to it very well. I read from the description of the same engine referred to in the patent of Mr. Corliss—*Armengand*, vol. 6, plate 12.

Mr. Curtis objected to this as not given in the notice.

Mr. Dickerson said he did not rely upon it as anticipating the plaintiff.

Witness: In this book it is described as making a cushion with compressed air, to prevent the slam of the valves. [Reads from French publication.]

414 *Cross-examined.*

1185 x Q. You have spoken of the experiments made in the use of the two dash-pots—Sickles' and Corliss'. When were those made?

A. Well, I cannot tell what year. It was at the time of one of the suits that was going on, either before Judge Nelson or Judge Grier.

1186 x Q. They were made with a view to your testifying in one of these cases?

A. I do not know if that was the particular view in which they were made. I did testify.

1187 x Q. Was it known to you that it was expected you would testify in relation to the dash-pot or air-cushion?

A. That I cannot say positively, but my impression is that it was.

1188 x Q. Did you not make those experiments with a view of using the evidence of them upon the trial?

A. I did not. I should not use the evidence.

1189 x Q. Were they not made with that view?

A. I believe they were.

1190 x Q. You testified to them?

A. I did. My impression is the testimony was taken in New Jersey.

1191 x Q. The purpose of introducing your evidence was to show the identity between the use of air and water?

A. I suppose that was the object, sir.

1192 x Q. You mentioned a difference in the adjustment necessary to be made for the purpose of using one or the other?

A. No, sir. I stated when we came to put in the water dash-pot, no matter whether Corliss' or Sickles', to adjust it properly, before commencing to run it, there was less difficulty in adjusting it exactly in the right place than there was when either Corliss' or Sickles' was used with air.

1193 x Q. Do you recollect whether the dash-pot you used in Sickles' dash-pot was constructed according to his specification?

A. It was, so far as my memory serves me. I remember
415 perfectly the Corliss dash-pot that that was constructed exactly.

1194 x Q. Do you recollect that in using water in the Corliss pot or arrangement it was constructed exactly according to his patent?

A. It was, as near as I can recollect.

1195 x Q. When you used Corliss' with water you put it in a tub of water?

A. Yes.

1196 x Q. Did you use them both under the same conditions?

A. Yes; both of them upon air and both on water.

1197 x Q. That is your way of making the conditions the same?

A. Certainly it is.

1198 x Q. [By Mr. Curtiss.] I want to inquire when you use Corliss' arrangement with air what adjustment you had to make?

A. It is necessary to have the dash-pot in a certain relative position to the position of the valve when the valve is covering its port, and you must therefore put the dash-pot in the precise position or make an adjustment in the rod that communicates from the valve to the dash-pot, and we found that a little more time was spent in making a correct adjustment with air than with water.

1199 x Q. When an engine is set up by the builder, and adjusted for running, and set in motion, is not that done once for all?

A. It is until the parts wear.

1200 x Q. [By Mr. Dickerson.] That is true in all arrangements?

A. It is.

1201 x Q. Is there not in the Sickles patent capacity for adjustment?

A. Yes, sir.

Mr. Thurston put in evidence questions 37 and 38, and the
416 answers to those interrogatories, with the drawing annexed, from the proceedings in a former trial, to bring home to Mr. Corliss' knowledge of an air dash-pot, the same as that patented by him, prior to the date of his patent.

[The defendant rests.]

(Here follow eight (8) drawings referred to.